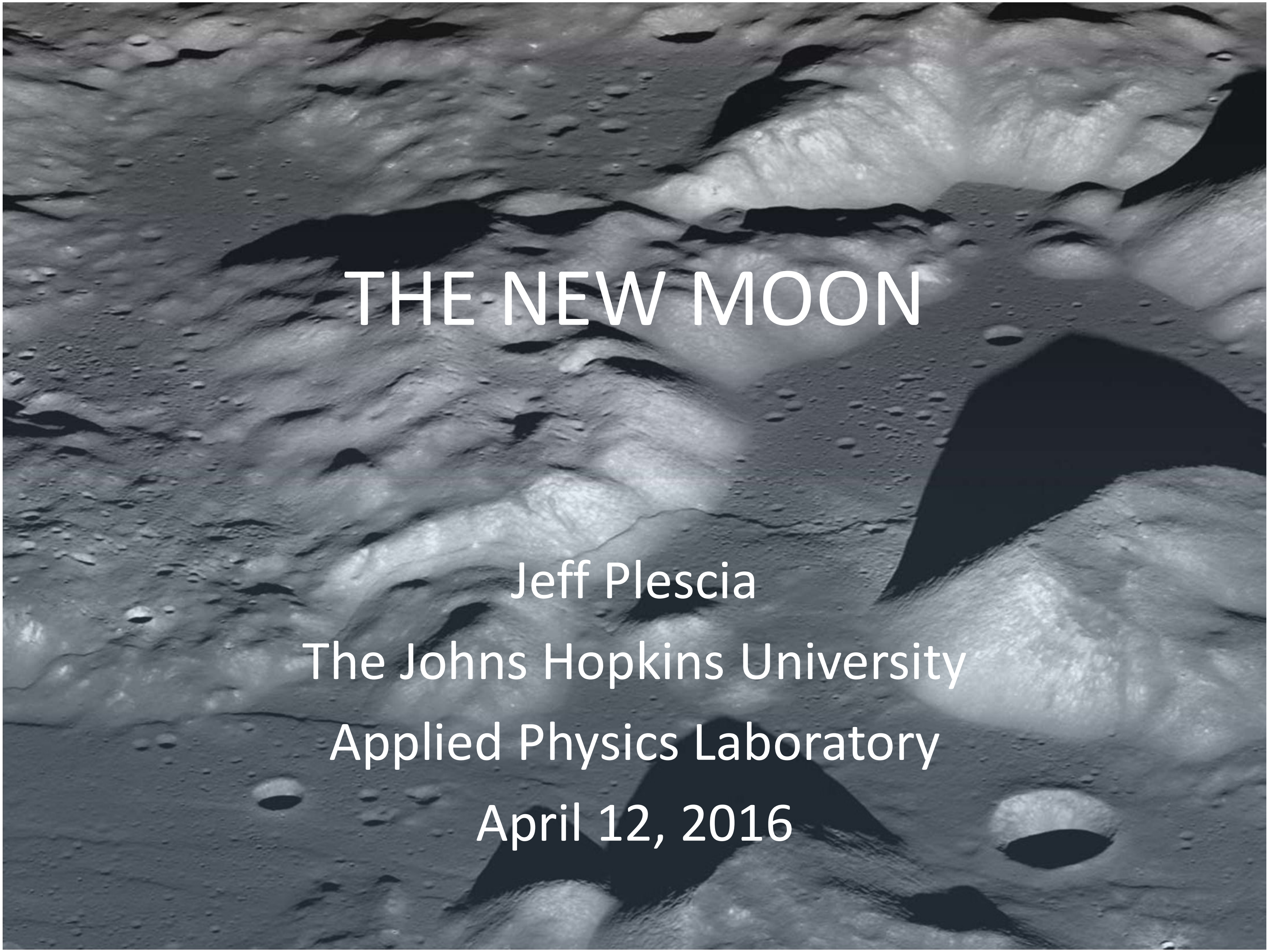


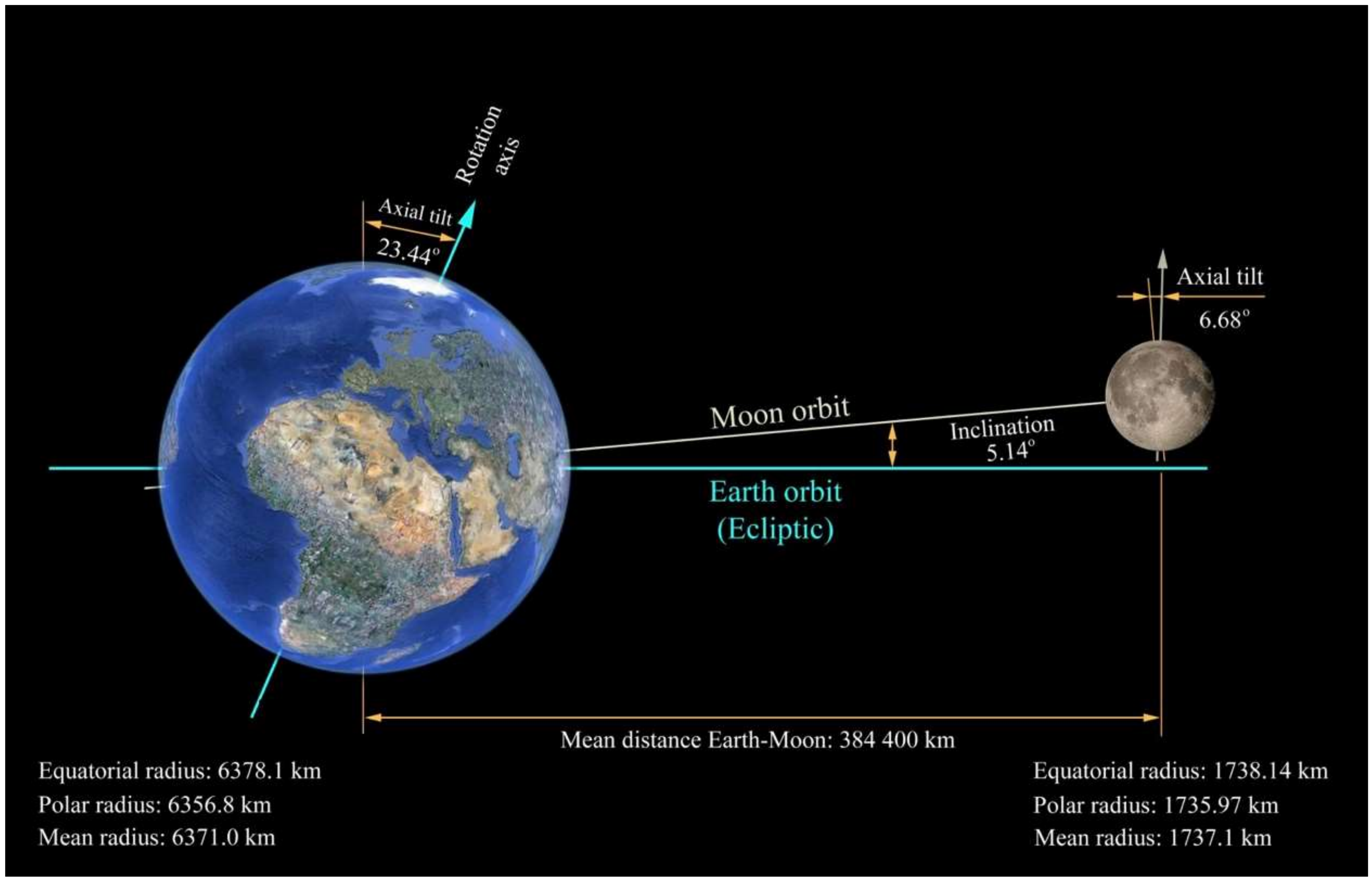
THE NEW MOON

Jeff Plescia
The Johns Hopkins University
Applied Physics Laboratory

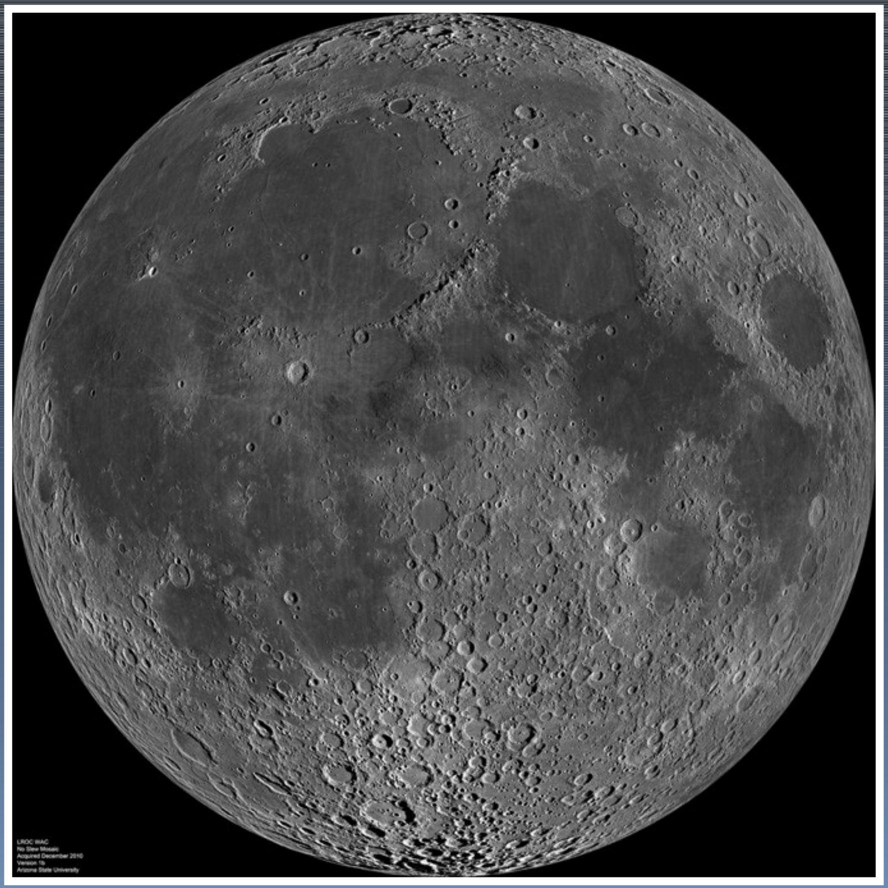
April 12, 2016

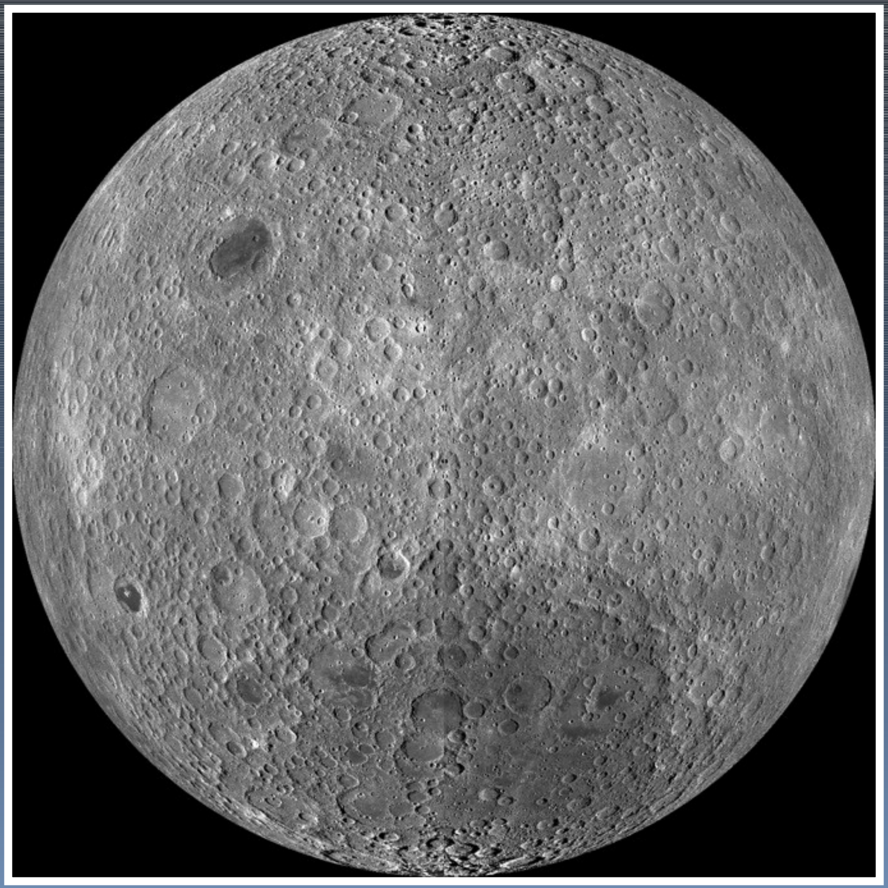
The View From The Earth

Moon’s Orbit


Rotation axis
Axial tilt
23.44°
Axial tilt
6.68°
Moon orbit
Inclination
5.14°
Earth orbit
(Ecliptic)
Mean distance Earth-Moon: 384 400 km
Equatorial radius: 6378.1 km
Polar radius: 6356.8 km
Mean radius: 6371.0 km
Equatorial radius: 1738.14 km
Polar radius: 1735.97 km
Mean radius: 1737.1 km

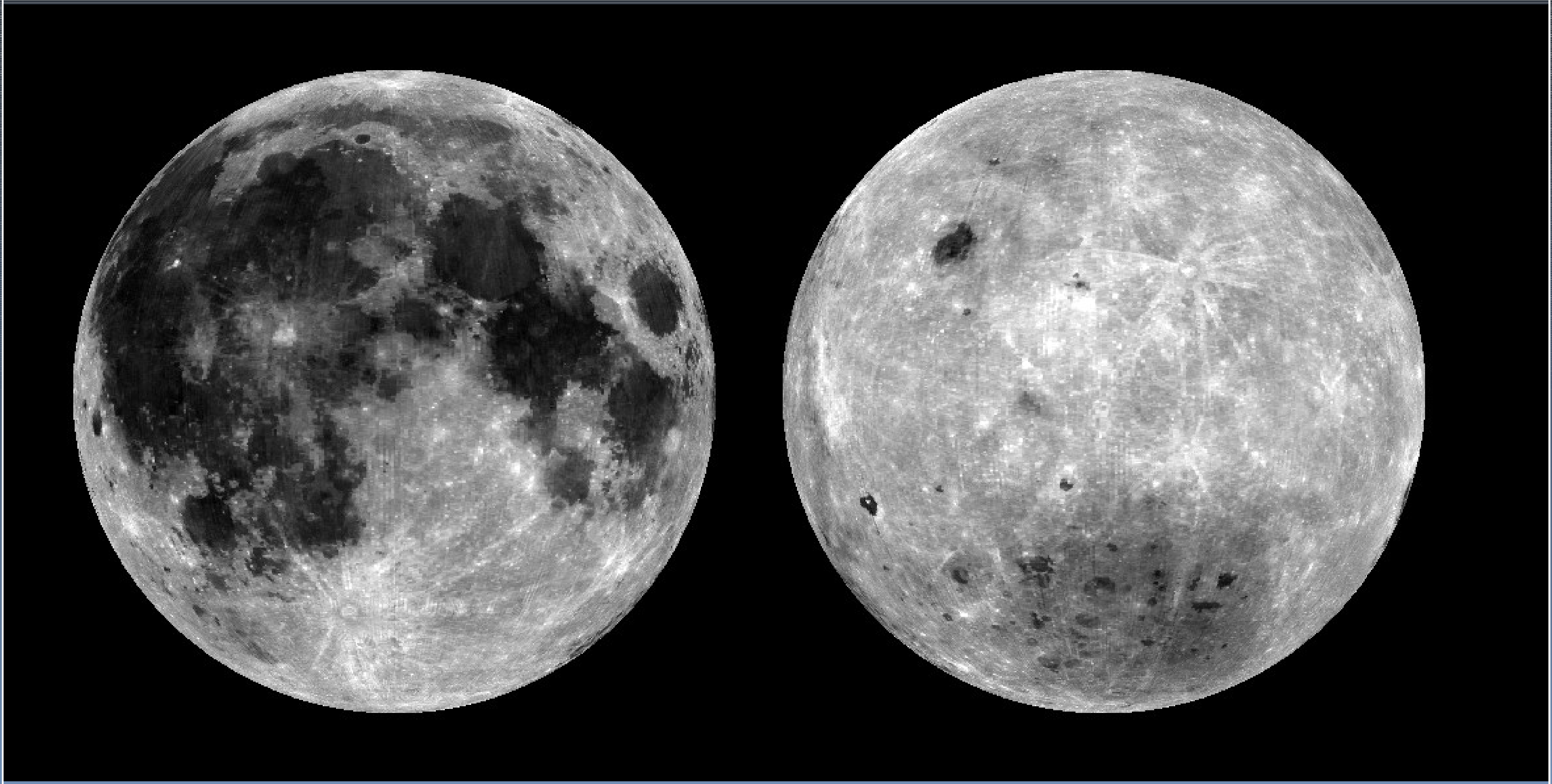
Nearside – Farside - Sunlight





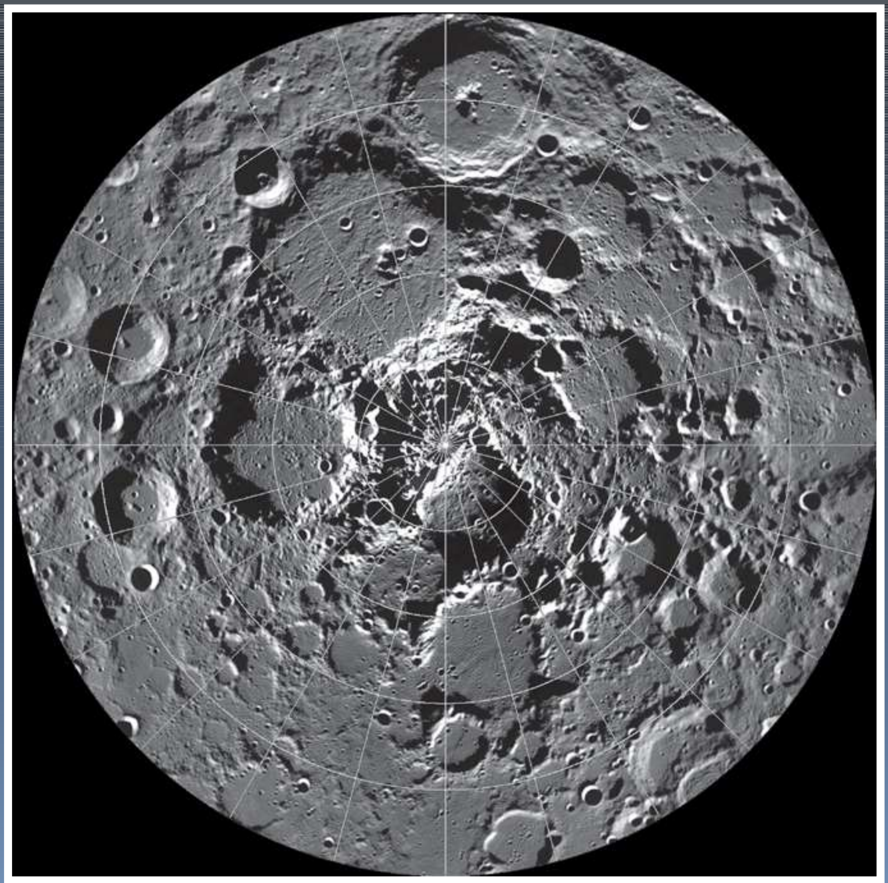
Every part of the Moon's surface was imaged at the same local time on the surface.
You would never see this view naturally.

Nearside – Farside - Laser

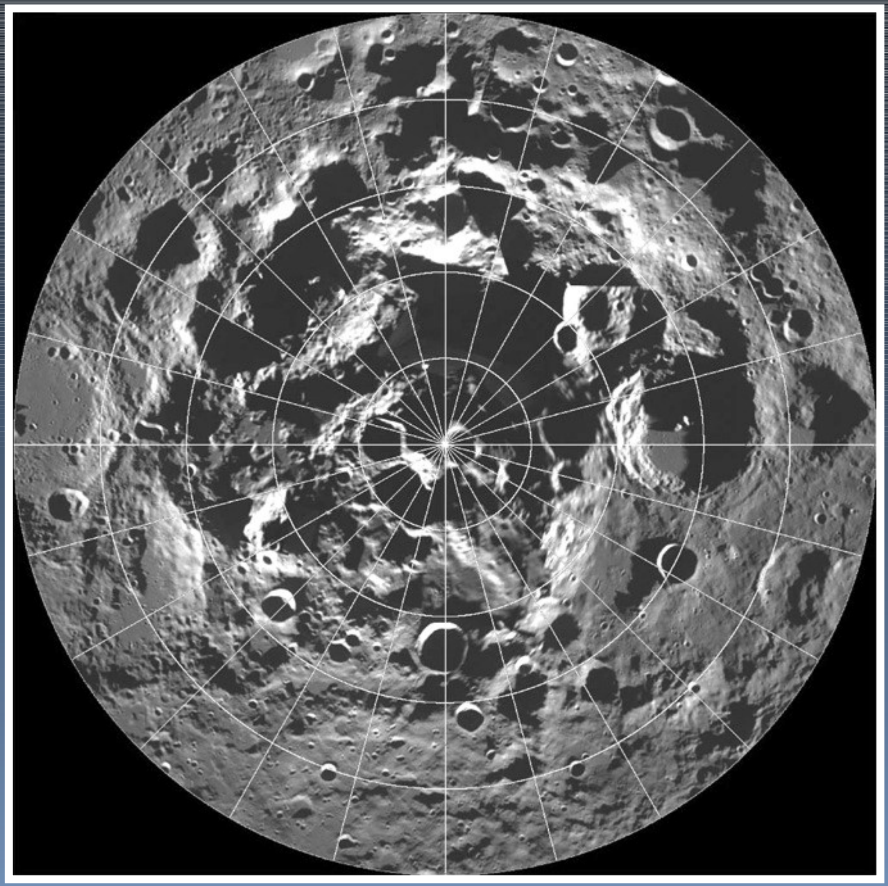


The laser beam, used to measure distance, reflects light back. This shows the surface illuminated by the laser from directly above the surface. Looks like the previous images.

The Poles - Sunlight



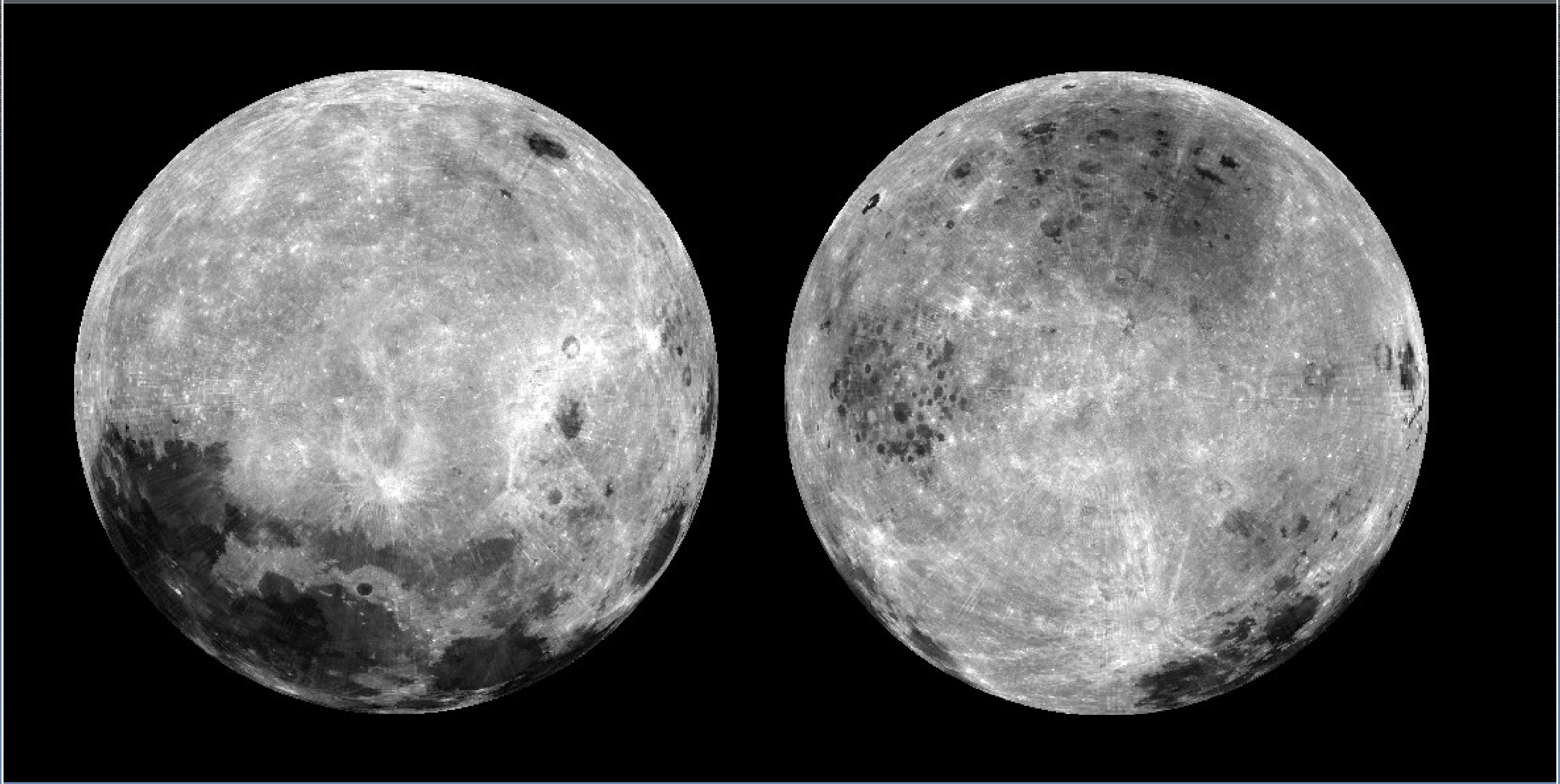
North Pole



South Pole

Every part of the Moon's surface was imaged at the same local time on the surface. You would never see this view naturally. But the Sun is always on the horizon – it never rises higher than 1.5° above the horizon. Because the Sun never rises very high, there are areas of permanent shadow.

The Poles - Laser

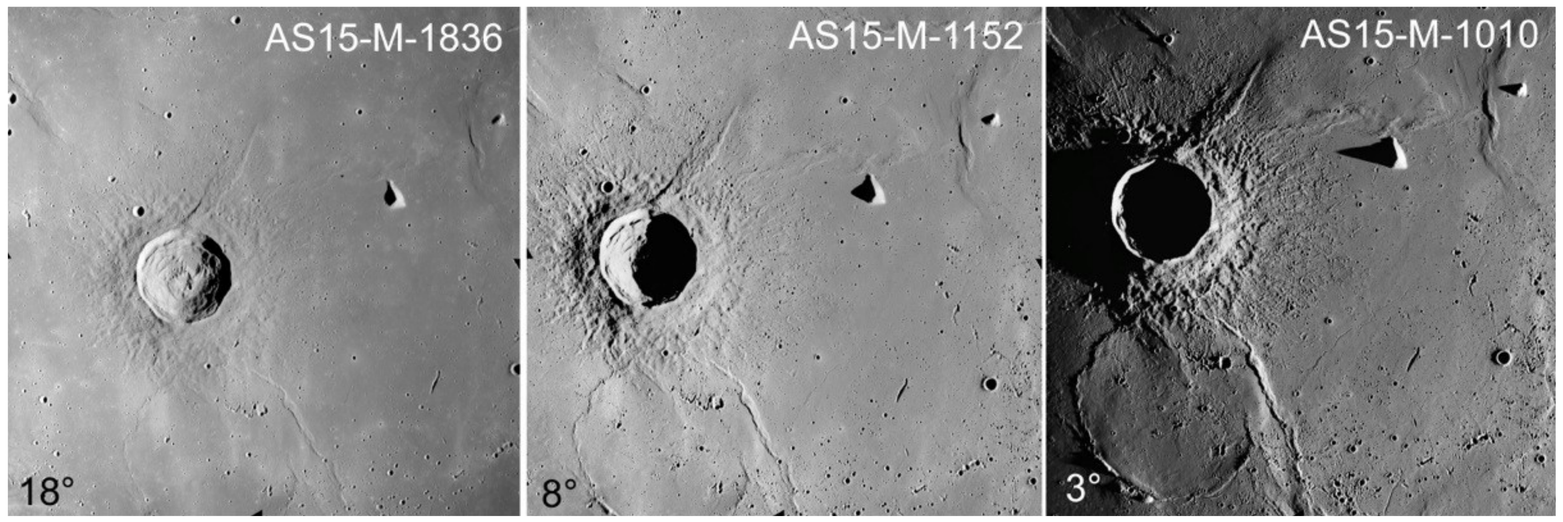


North Pole

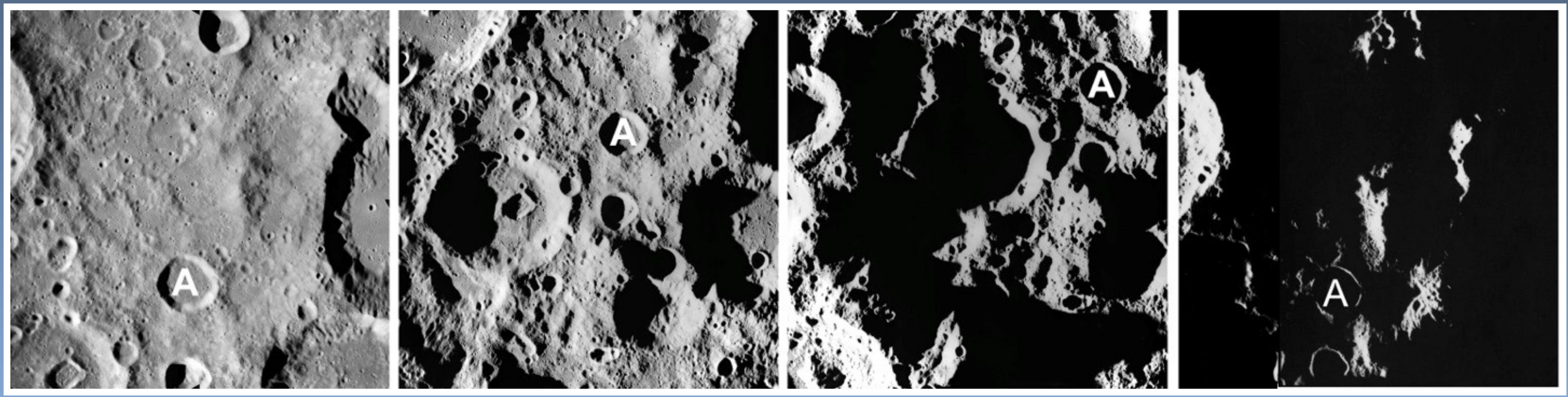
South Pole

The laser beam, used to measure distance, reflects light back. This shows the surface illuminated by the laser from directly above the surface. Because the laser on the spacecraft, it illuminates the surface from above and the shadows disappear allowing us to see into the areas of permanent darkness.

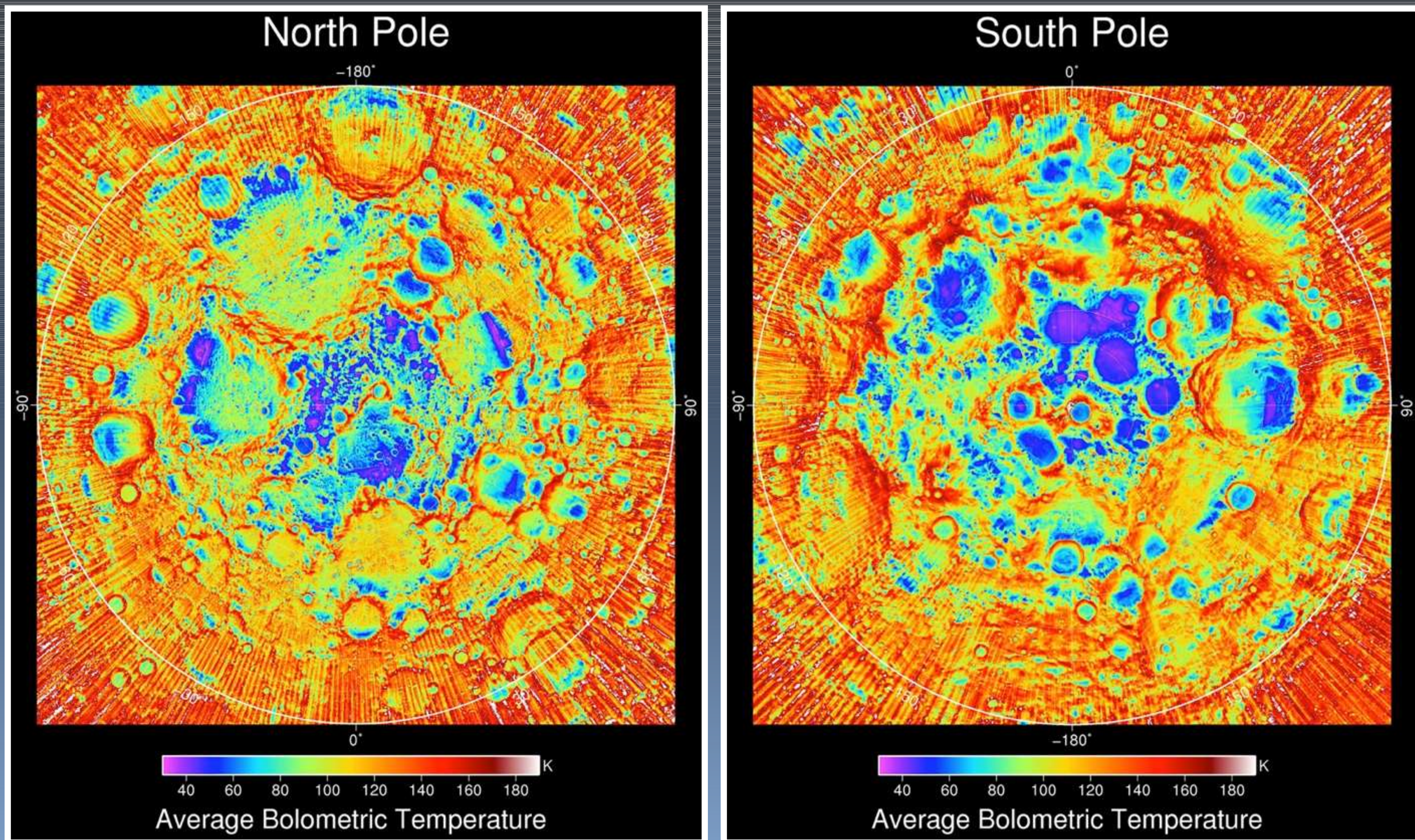
Illumination Effects



19° 8° 4° 1°



Average Polar Temperature

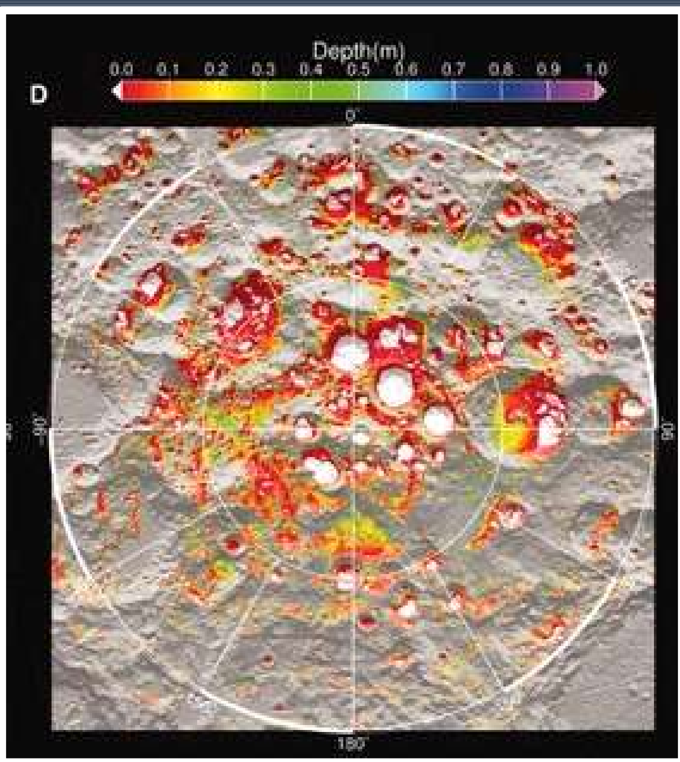


Polar Craters: 30K (-405° F) Pluto: 44 Kelvin (-380° F).

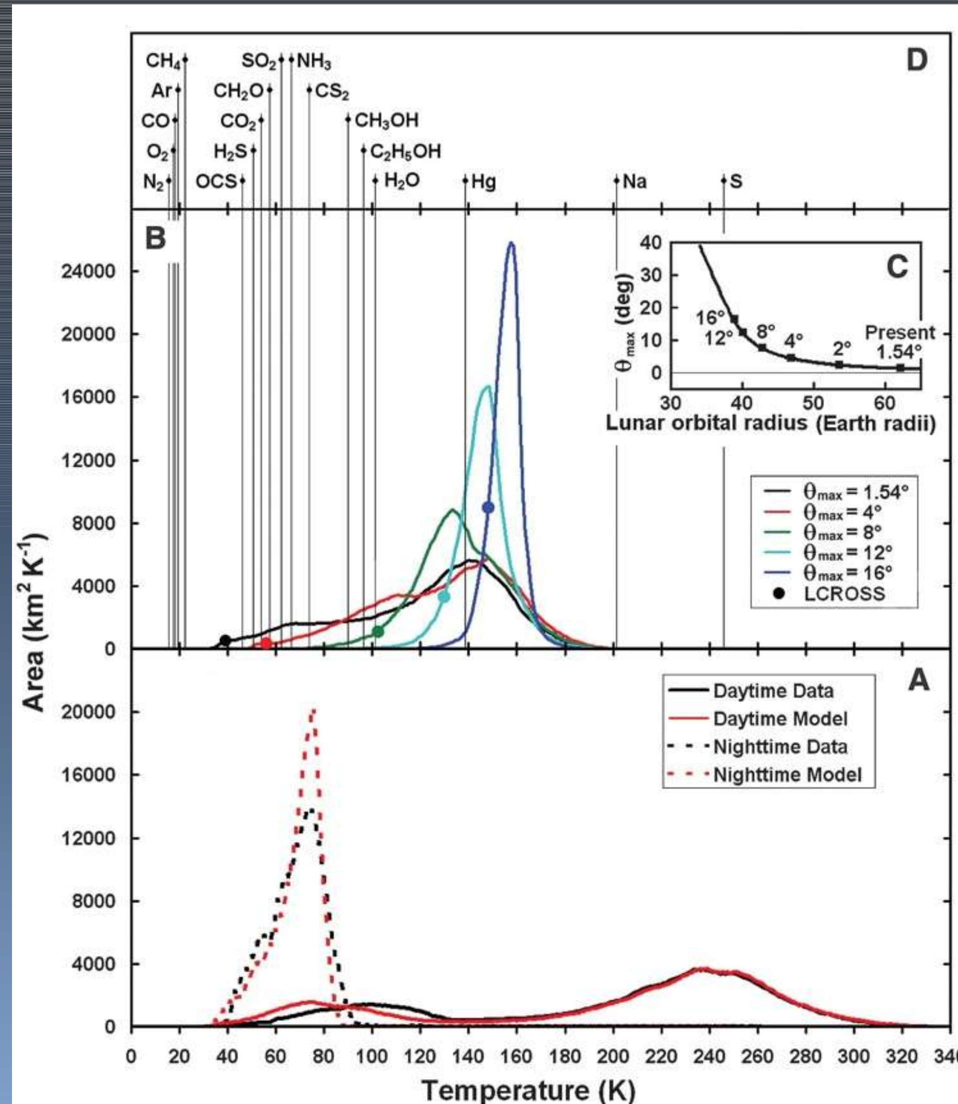
Polar Temperatures

LRO Diviner temperature measurements and thermal analysis

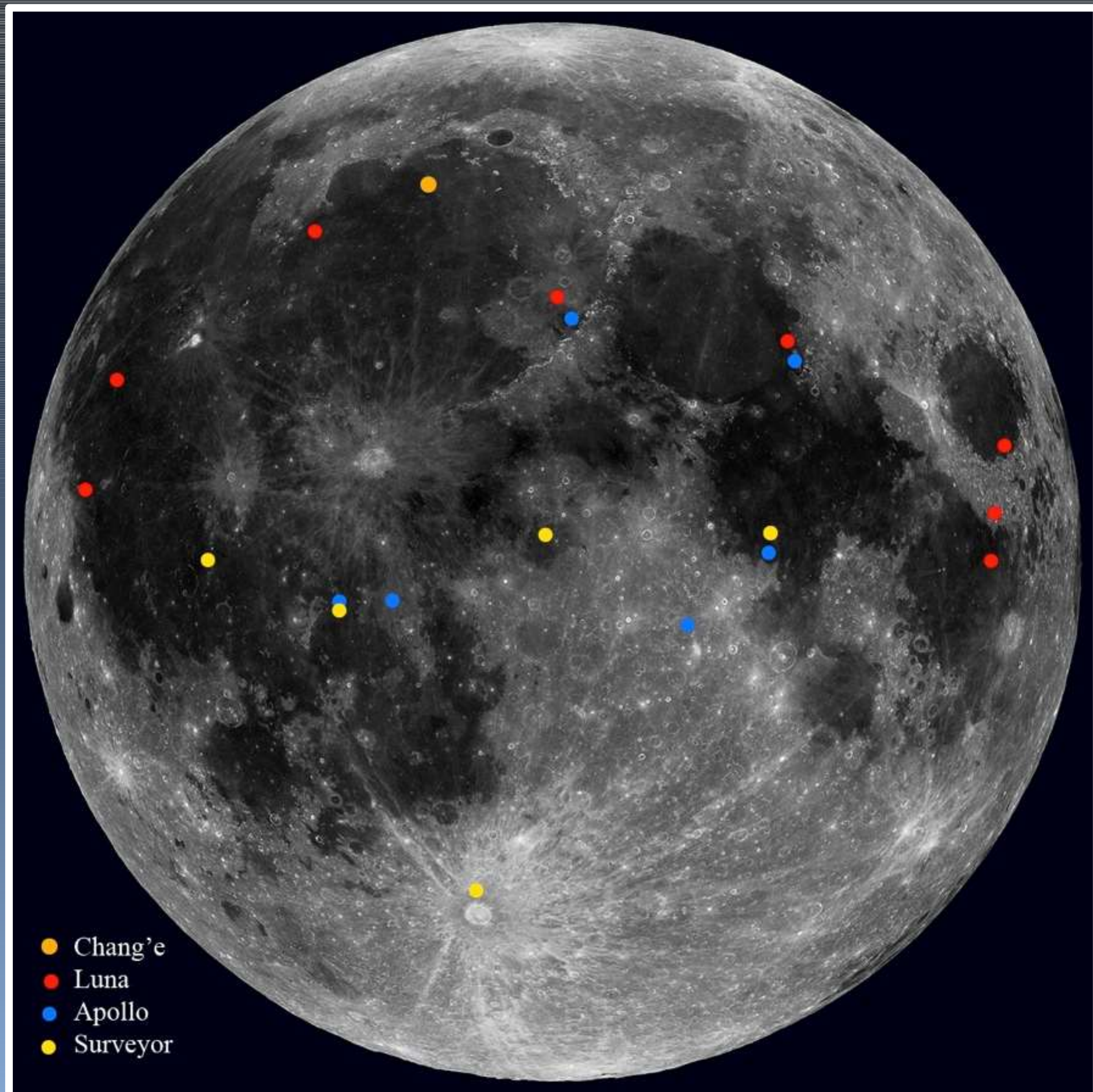
- Provides map of where different compounds are stable against sublimation.
- Modeling predicts the depth to a thermally stable layer.



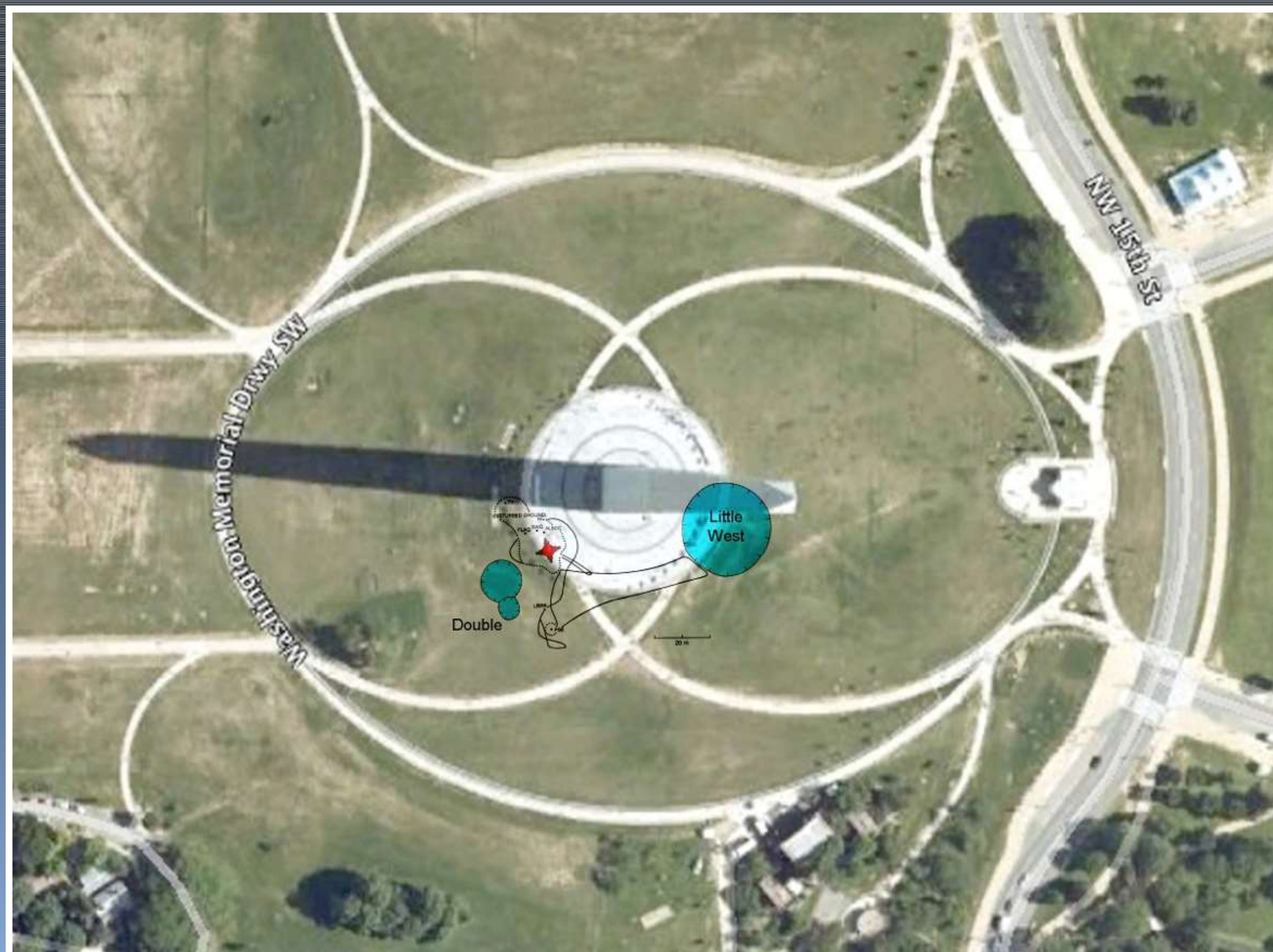
Depth to freezing



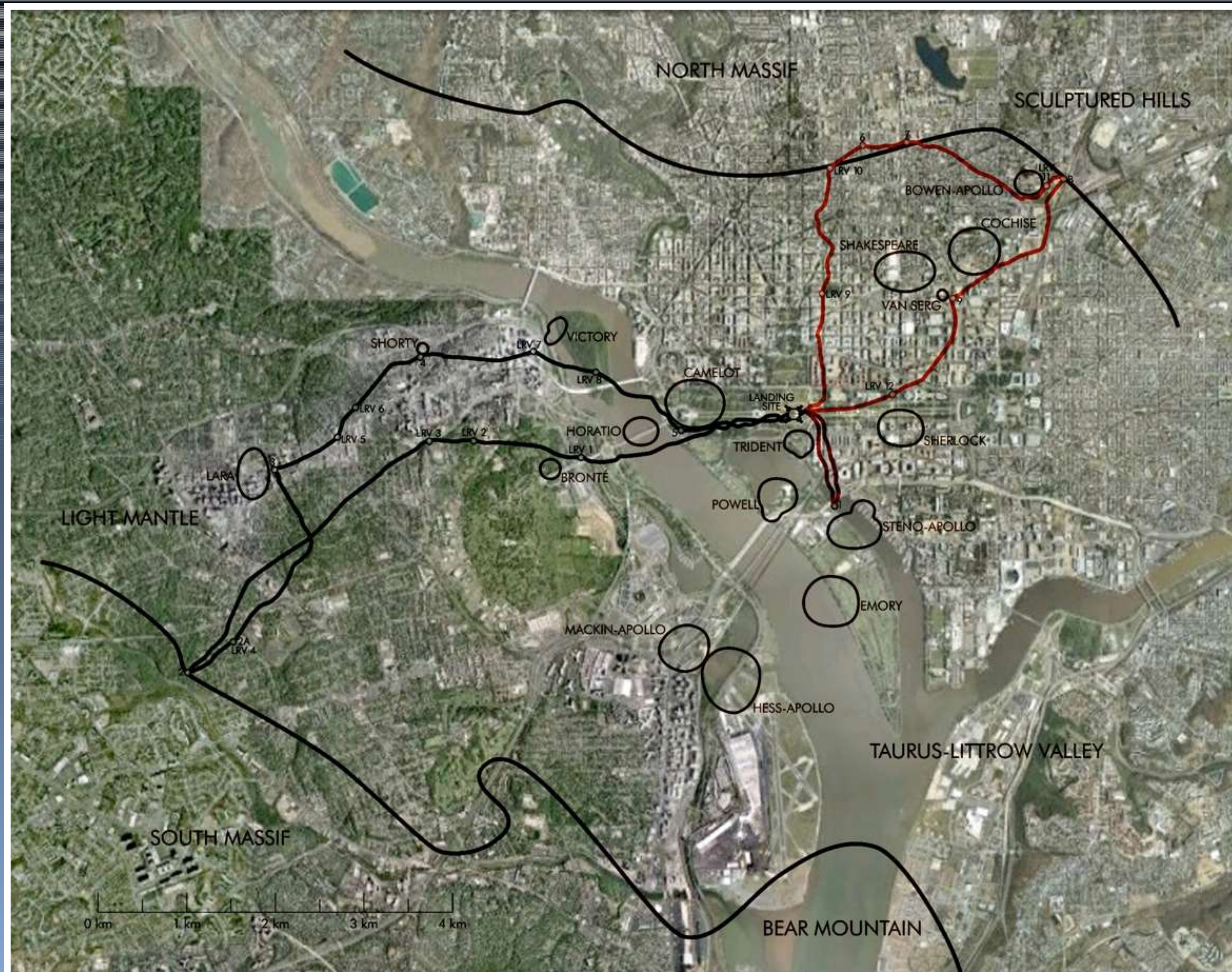
Landing Sites



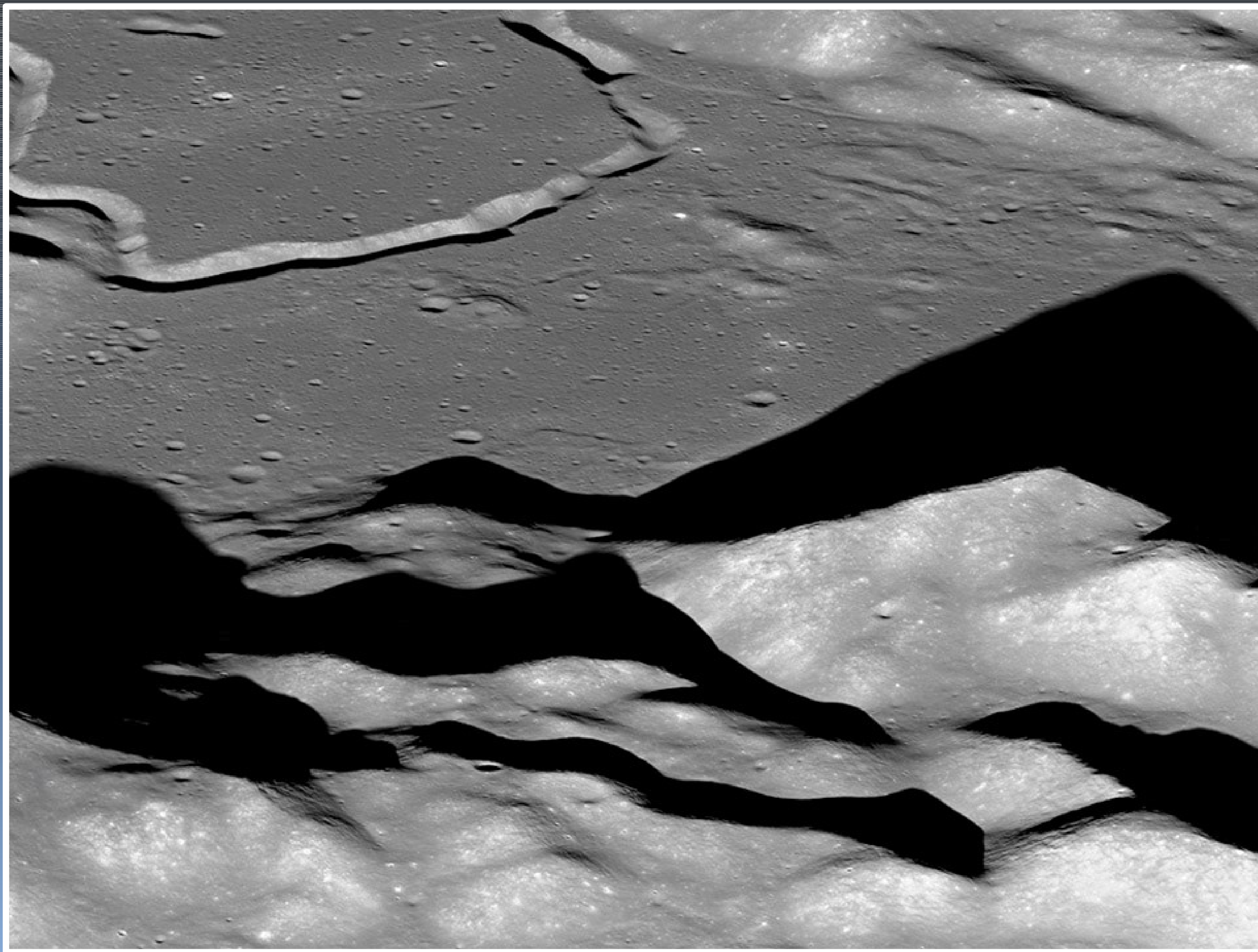
Apollo 11 Traverse



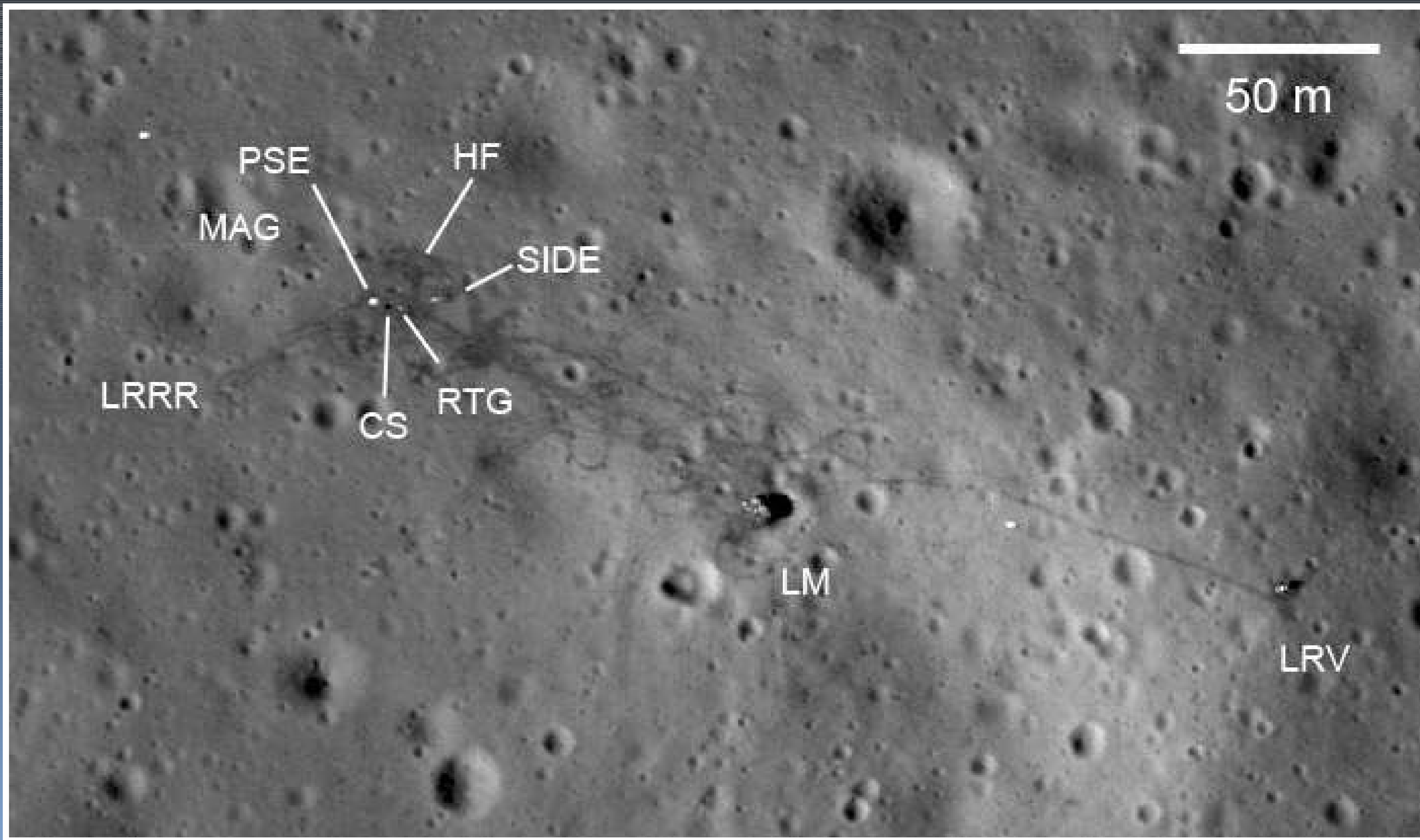
Apollo 17 Traverse



Apollo 15

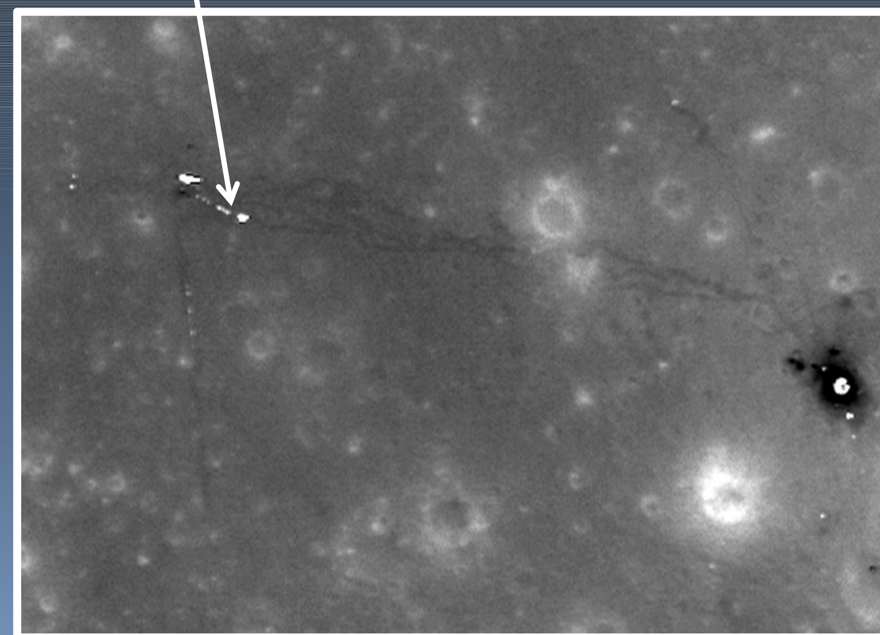


Apollo 15



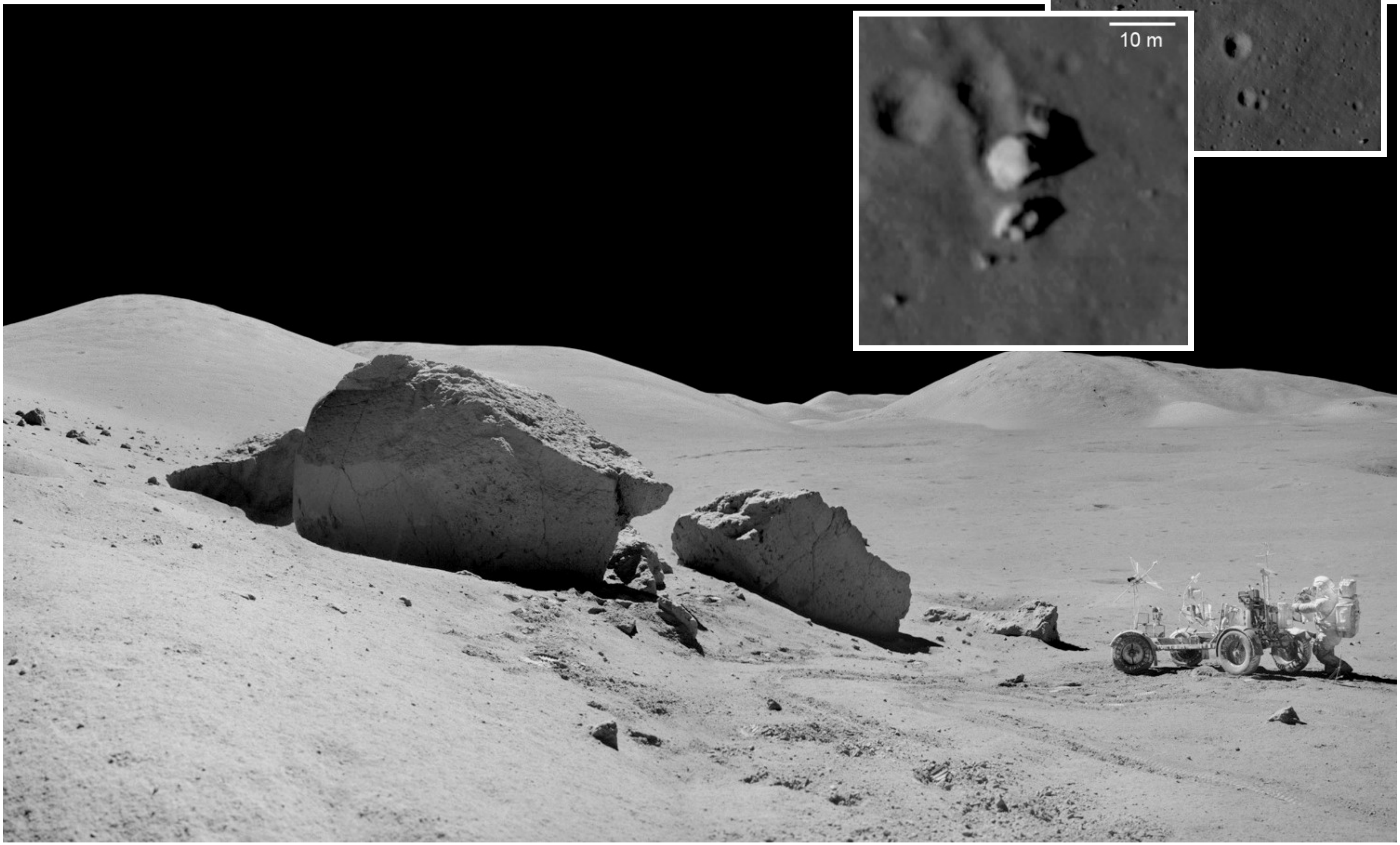
Apollo 14 Site

Wire ribbon



The ribbon wire was laid out across the surface to connect experiments. It’s flat shinny surface reflects sunlight, and is visible 45 year later.

Apollo 17 – Station 6



Saturn SIVB

Saturn IB (Stage 2)

Saturn V (Stage 3)

Height: 17.8 m

Diameter: 6.6 m

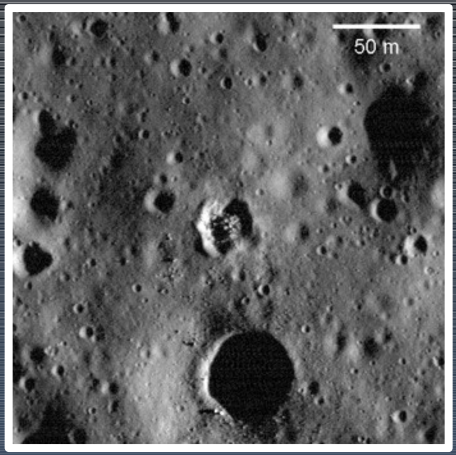
Mass (Wet): 119,900 kg

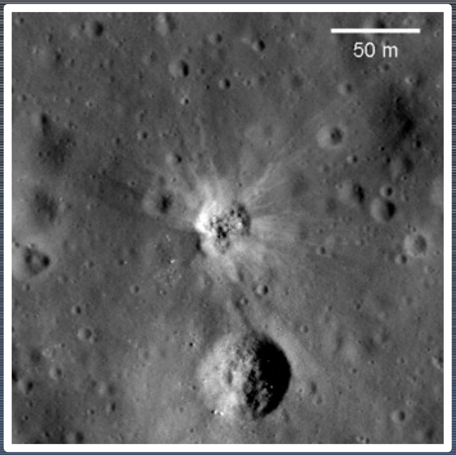
Fuel: LOX / LH_2

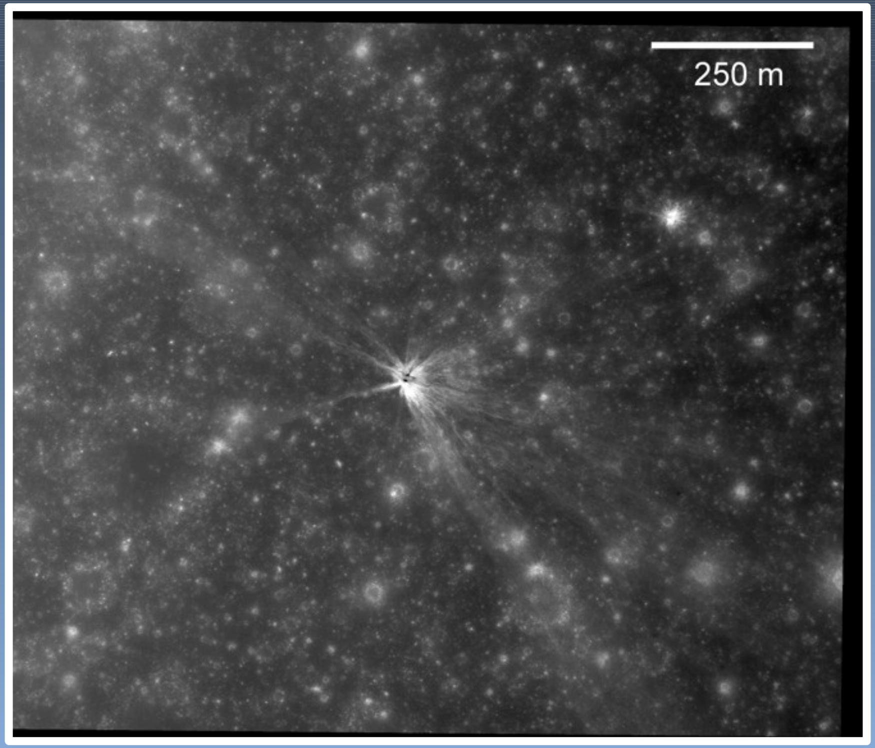
Mass (Dry): 14,000 kg

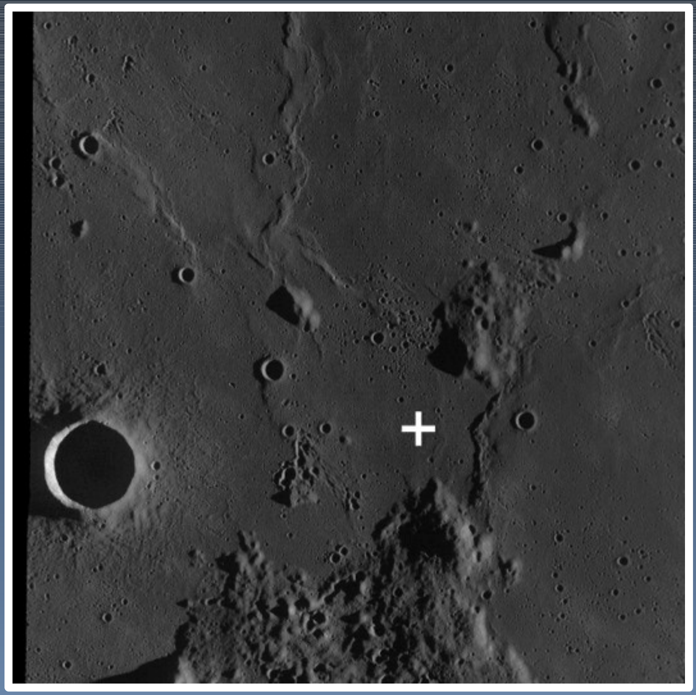
Bulk Density: 20 kg m^{-3} (0.02 g cm^3)

Apollo 15 SIVB Crater



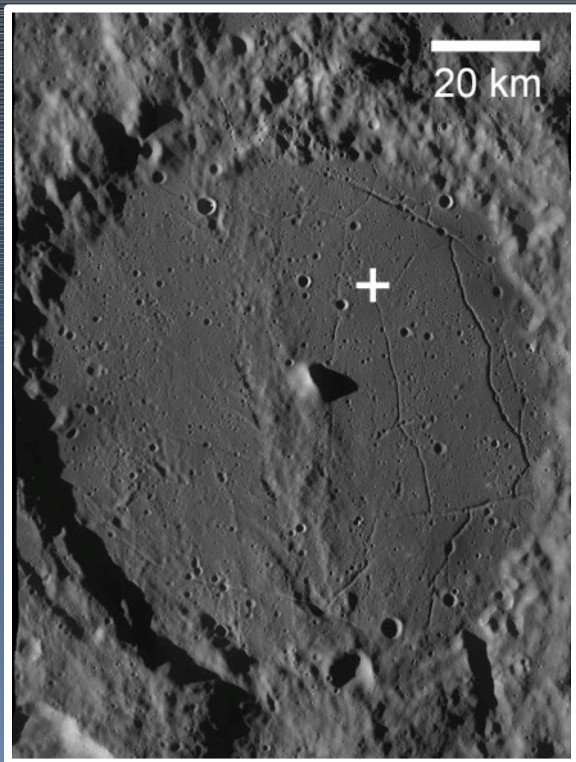


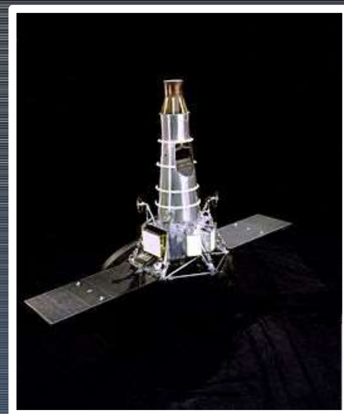


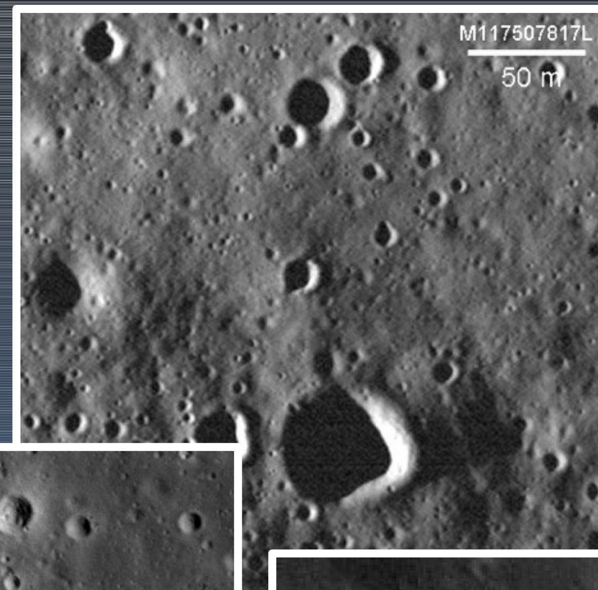


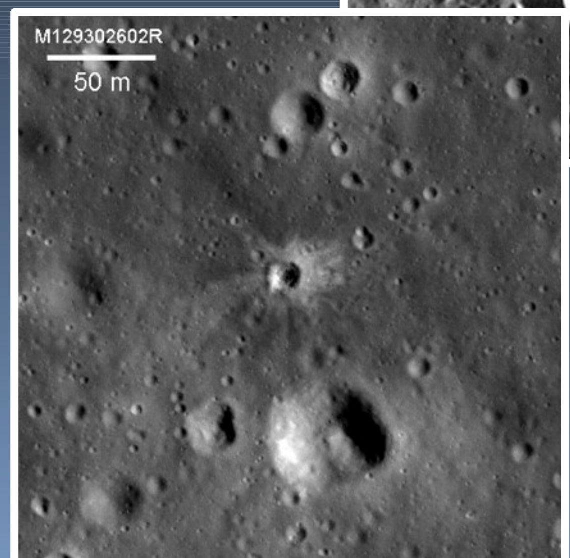
July 29, 1971
Sinus Aestuum

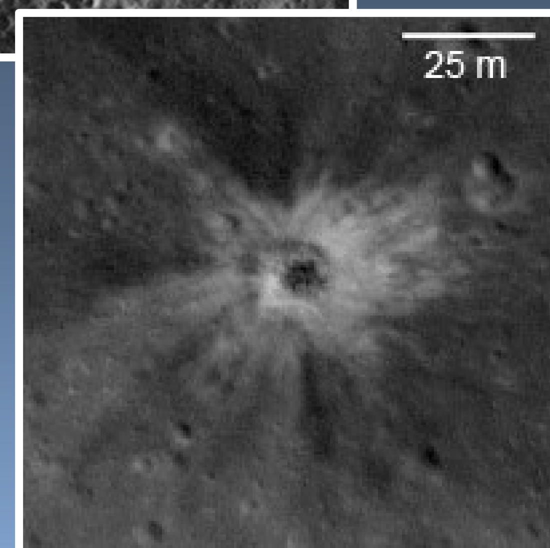
Ranger 9 Impact Crater





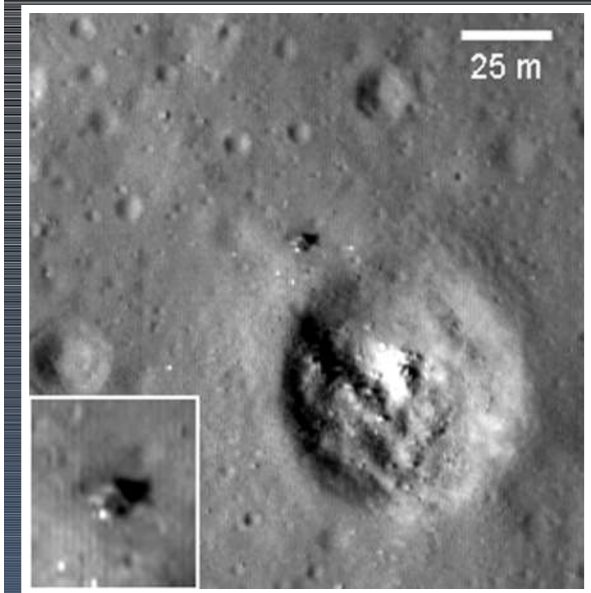




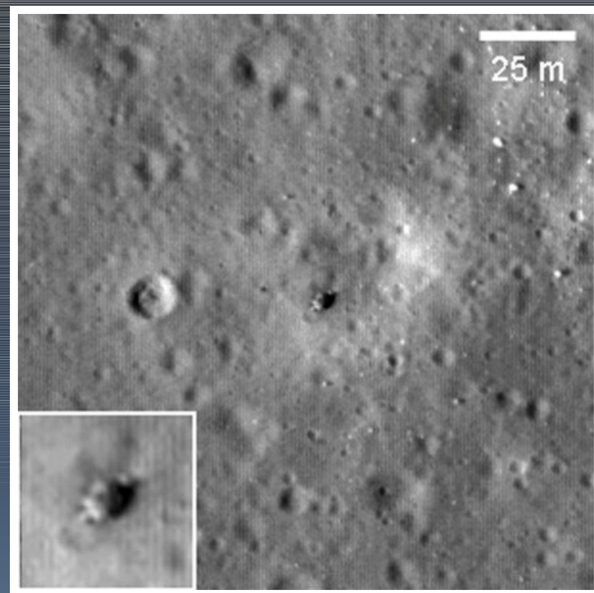


Alphonsus Crater Floor
March 24, 1965

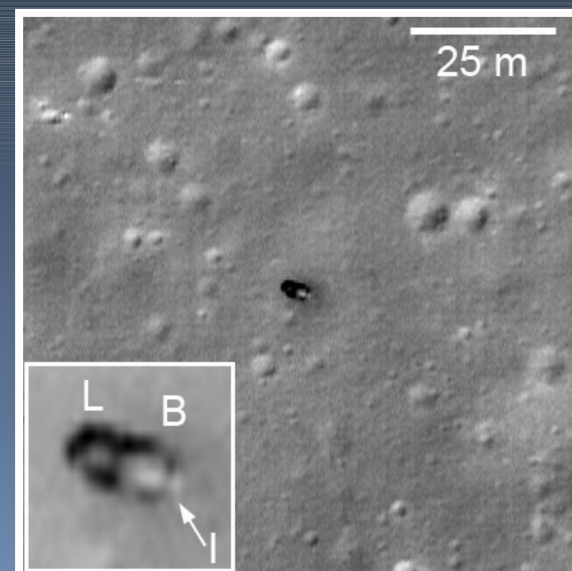
Soviet Lunar Missions



Luna 24



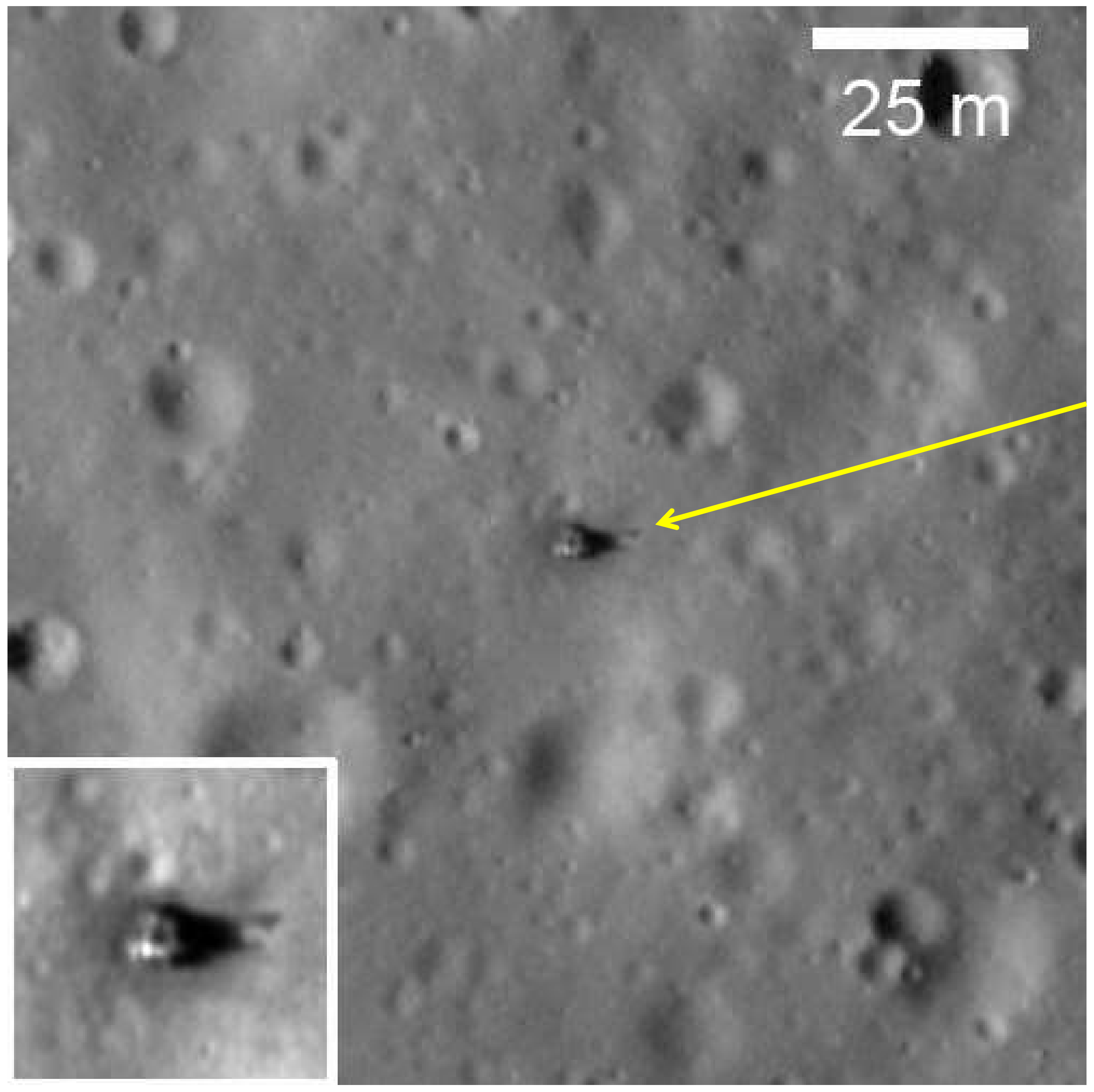
Luna 23



Lunokhod 2

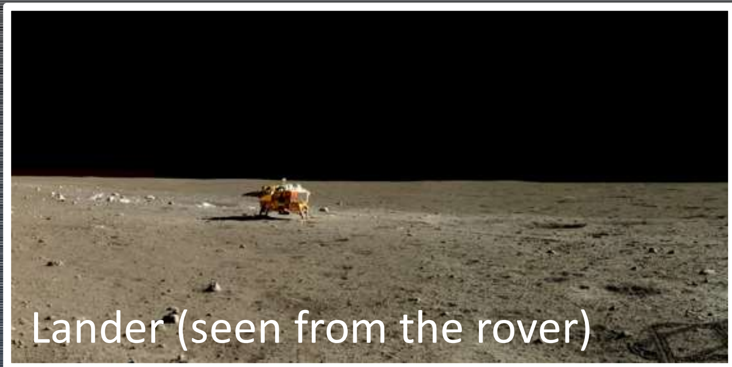

Luna 23

Luna 20

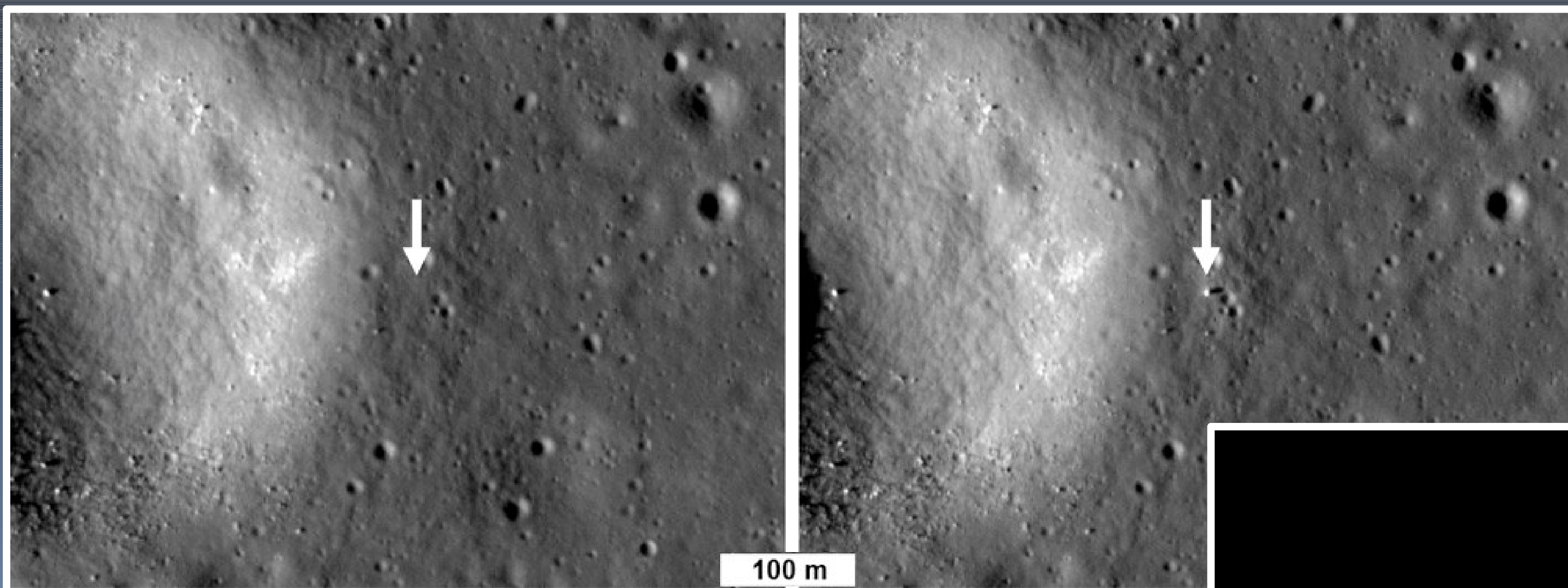


You can see the shadow of the sampling mechanism

Chang'E

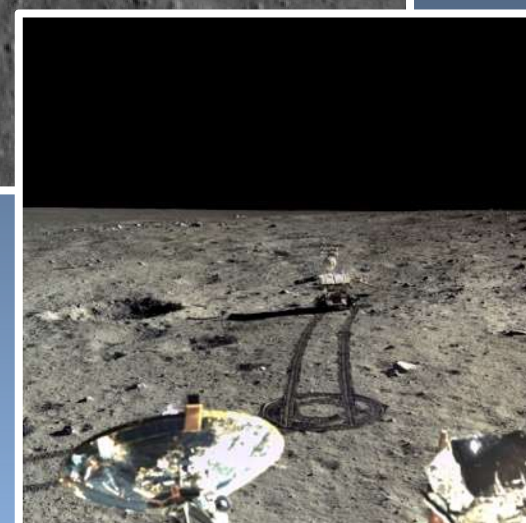


Lander (seen from the rover)



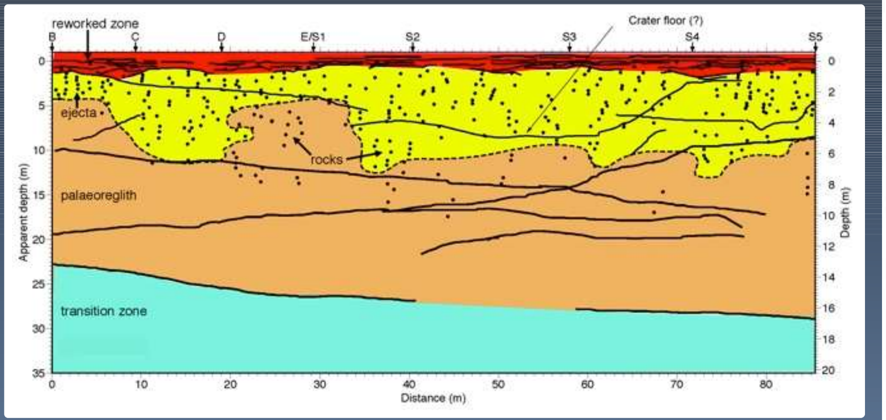
Before landing

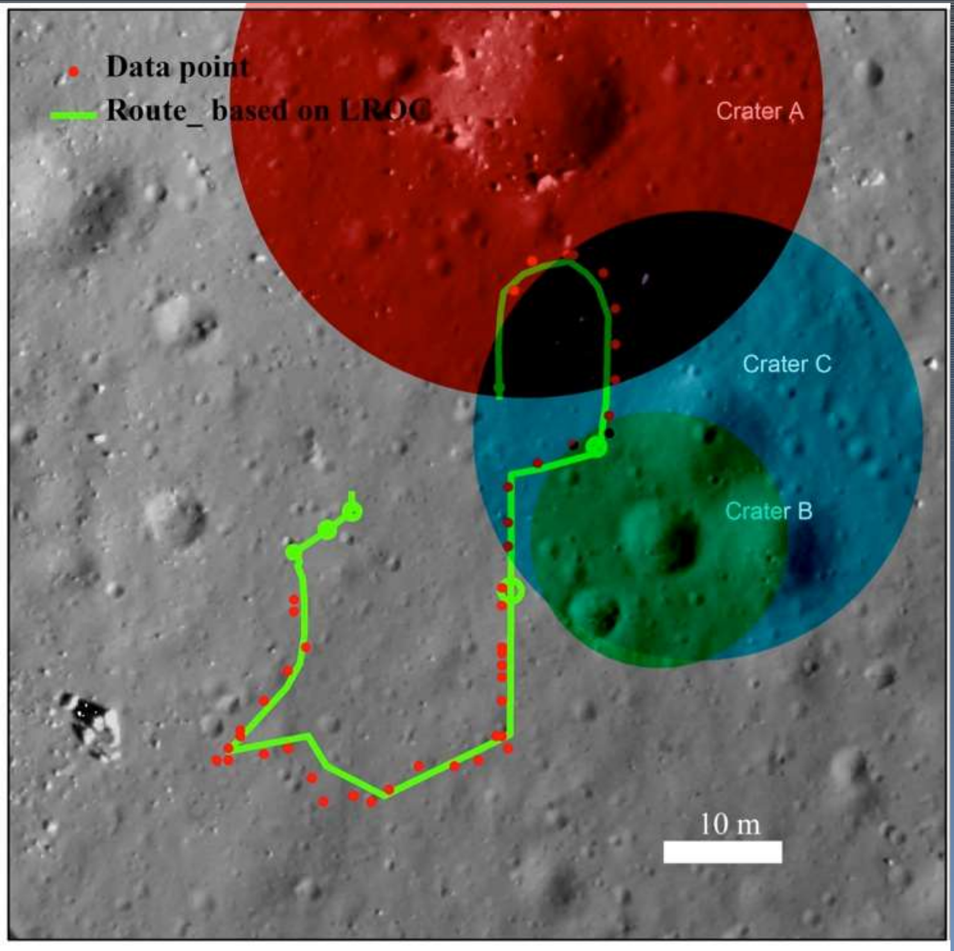
After landing



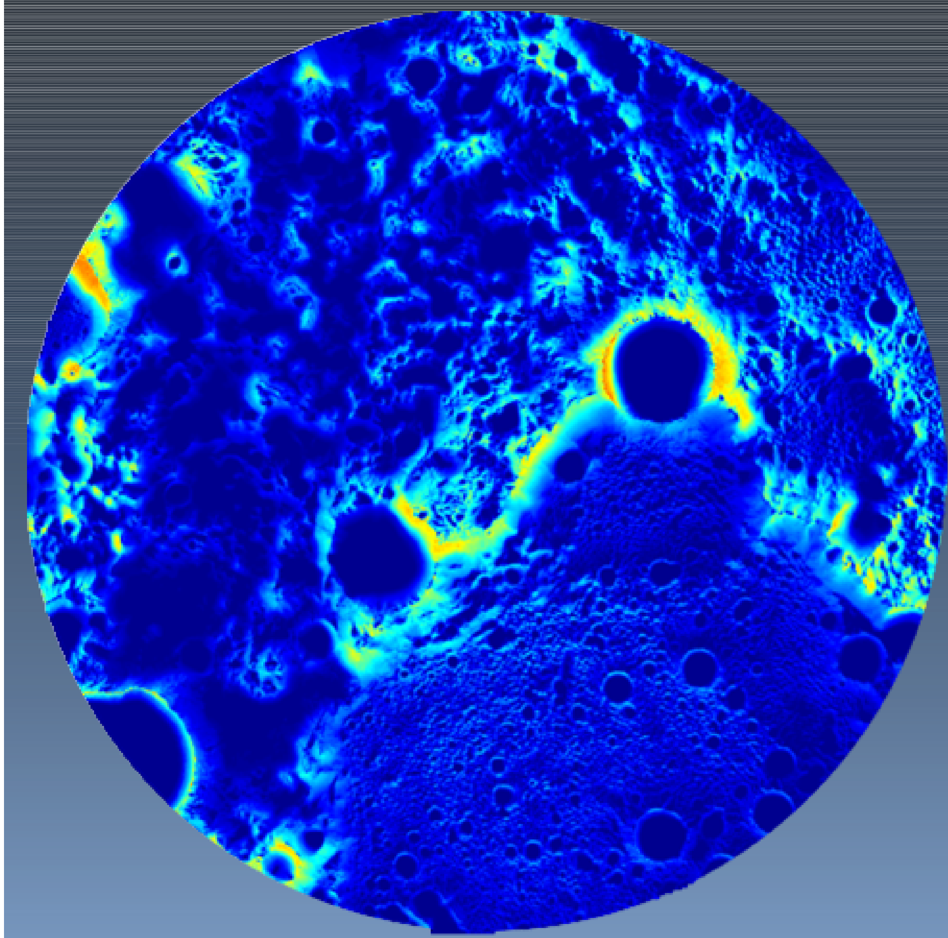
Rover seen from the lander

Yutu - Ground Penetrating Radar

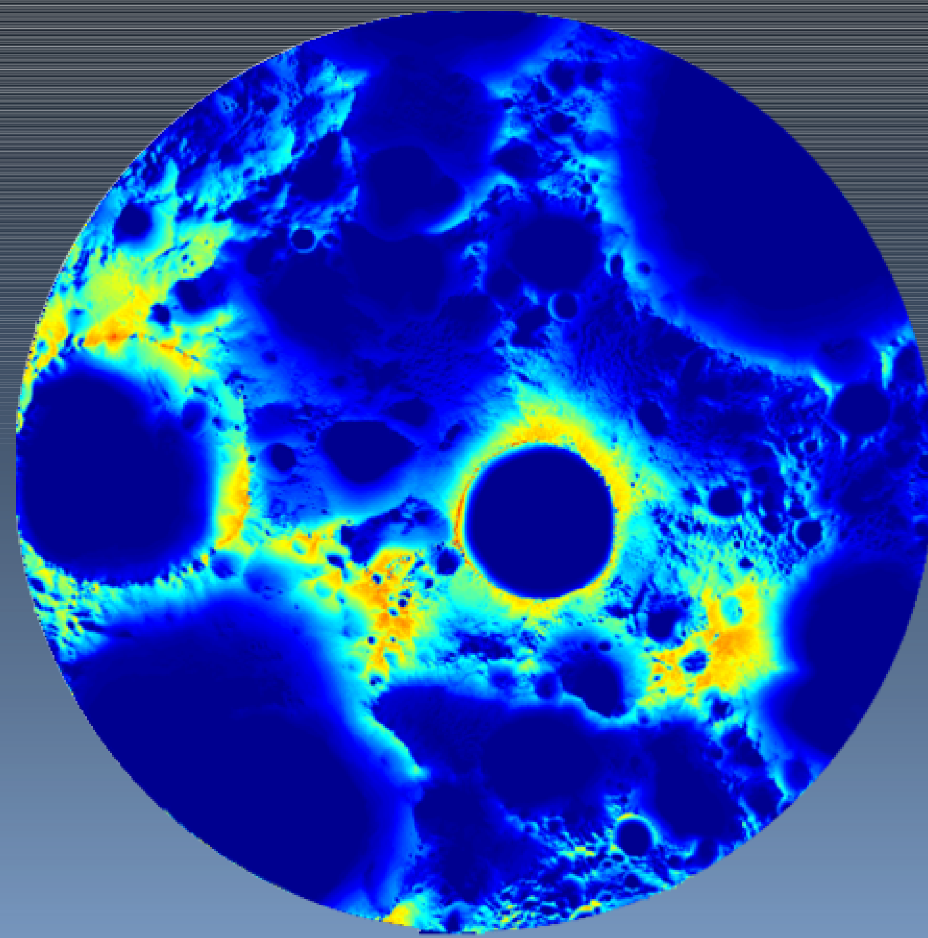




WAC Illumination Maps
Feb 2010 - Jan 2011

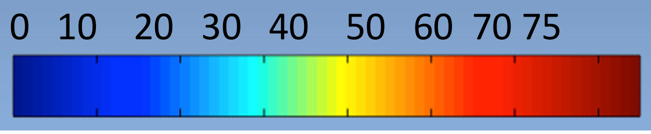


North Pole

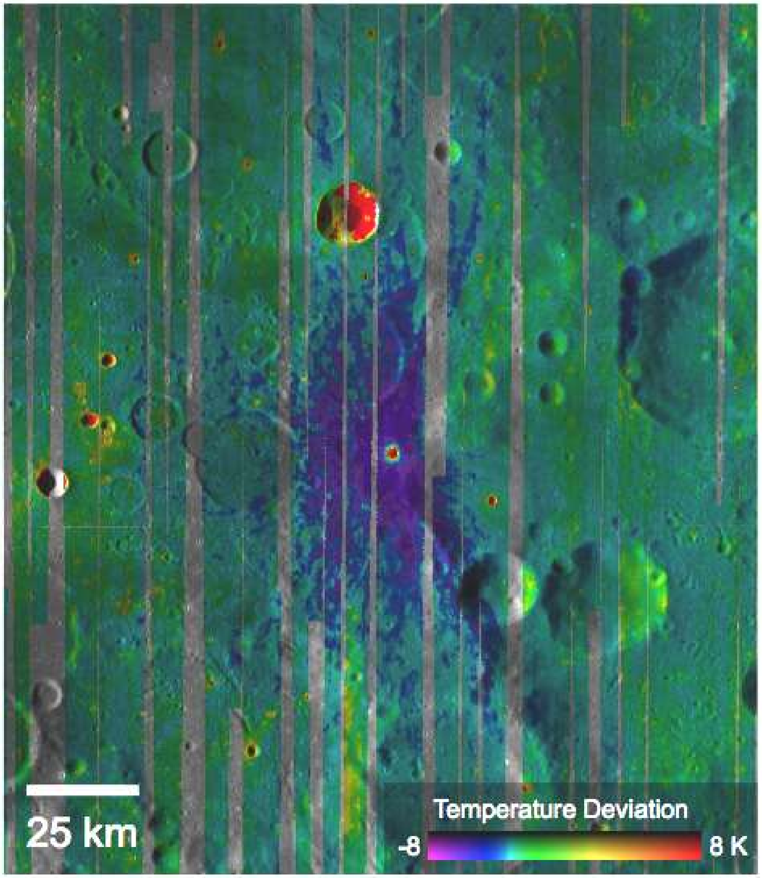


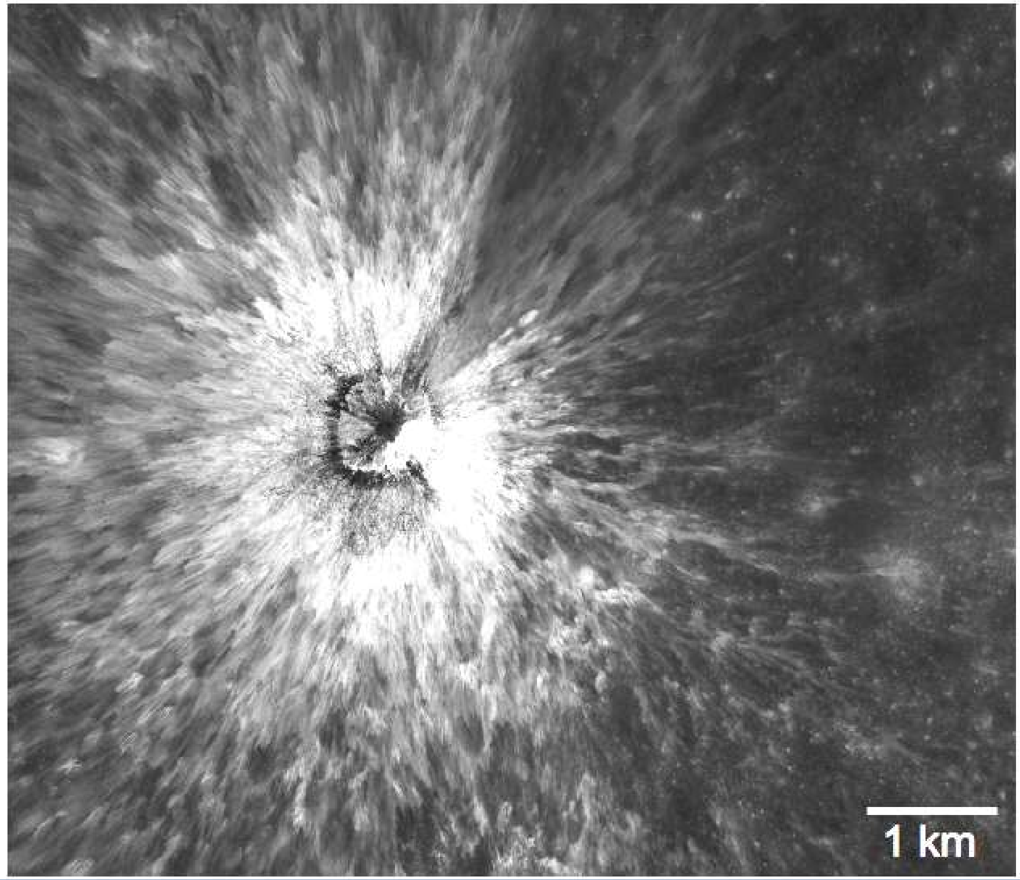
South Pole

The illumination maps extend from 88°N/S to the pole.



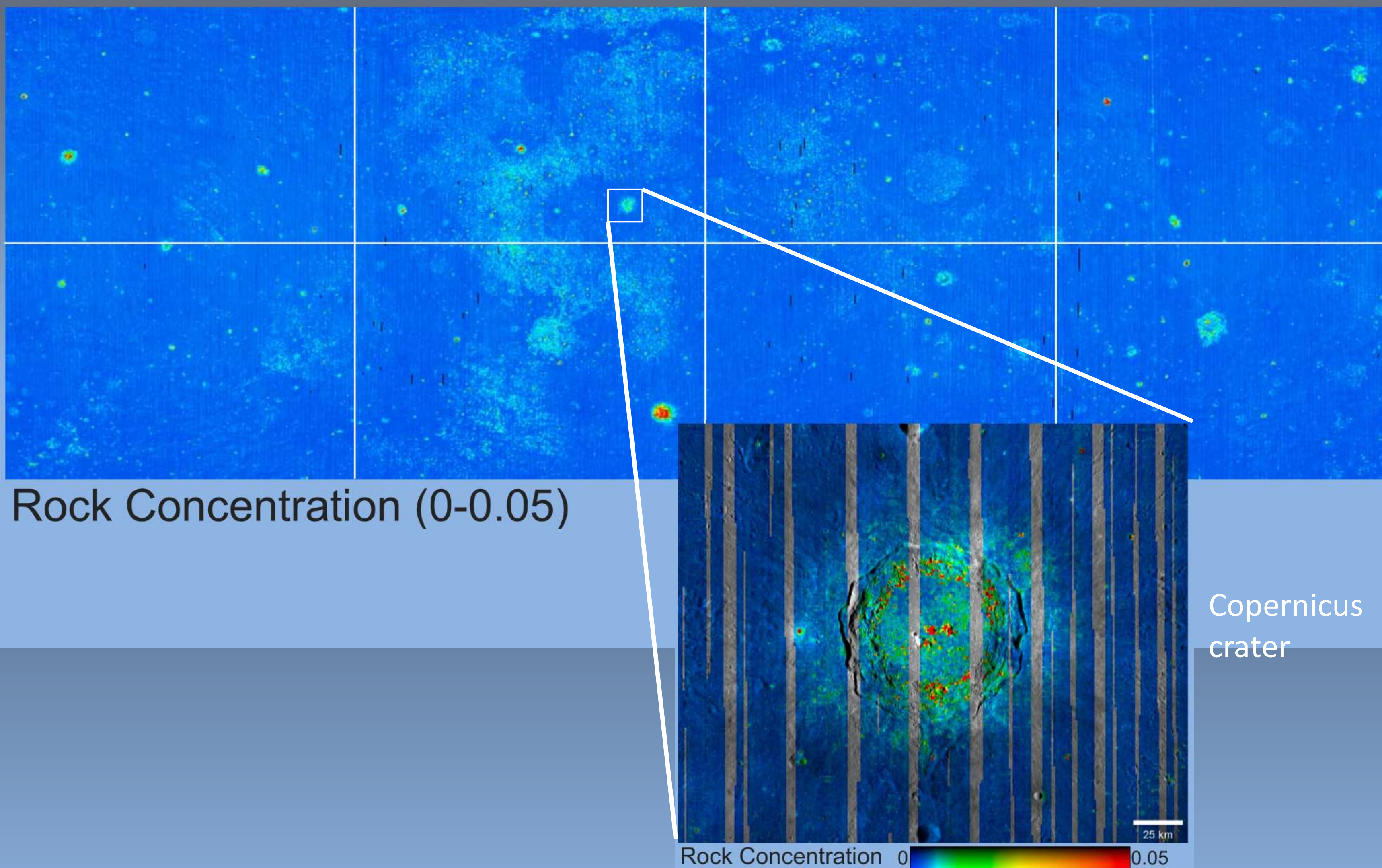
Diviner Thermal Anomalies





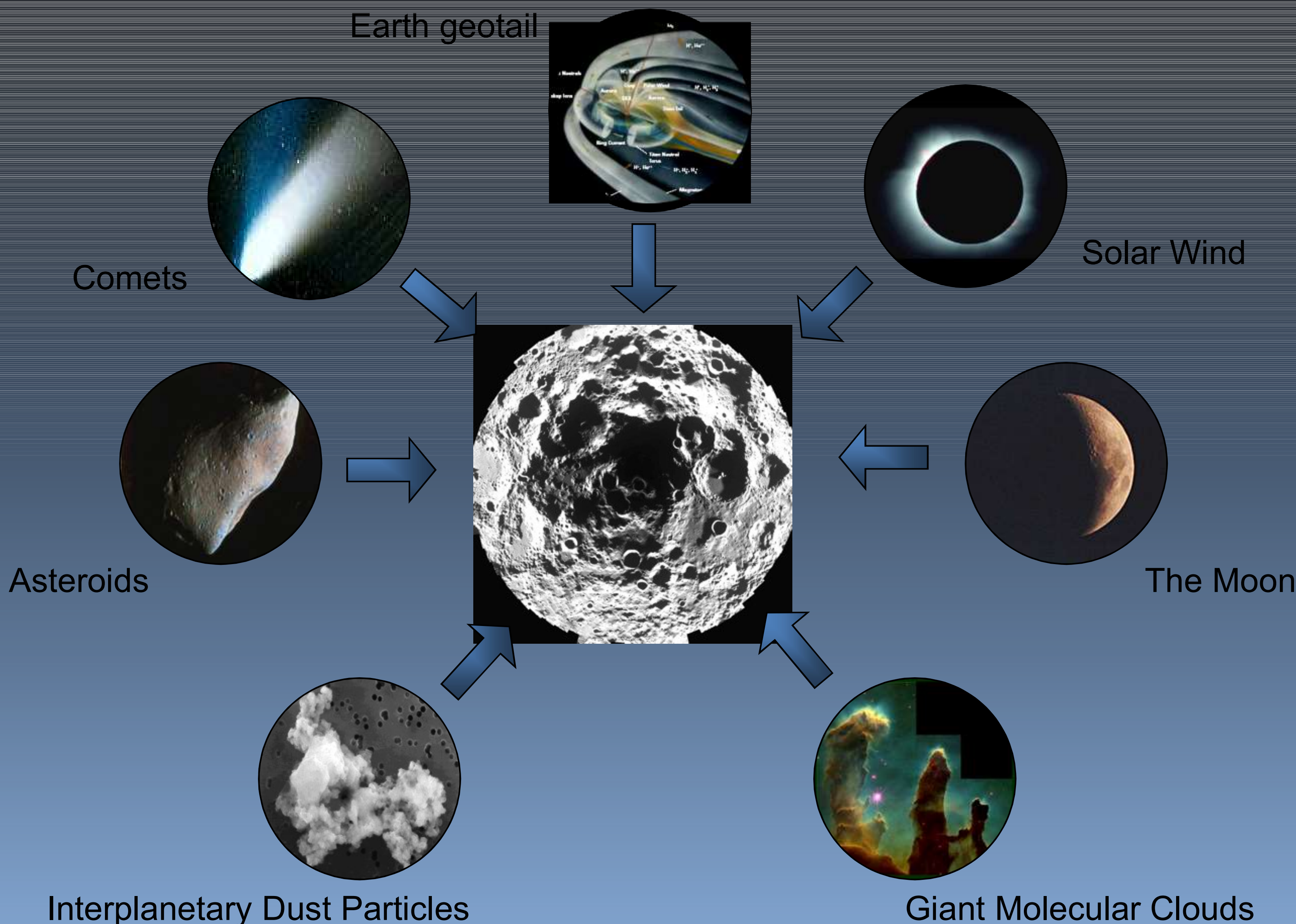
Large (100's of crater radii) regions around some fresh craters are unusually cold at night.

Surface Block Abundance



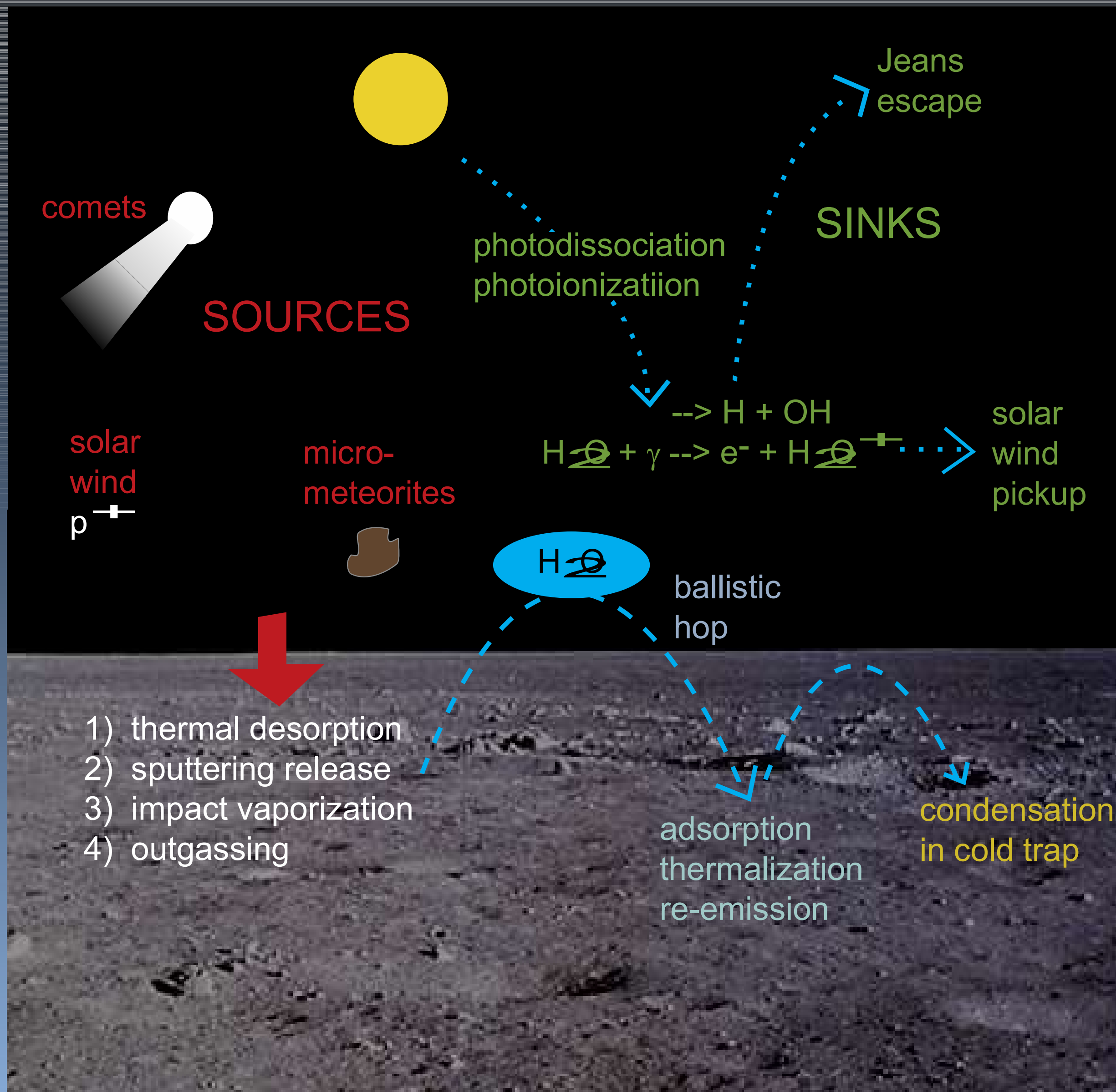
Copernicus crater

Sources of Lunar Polar Volatiles

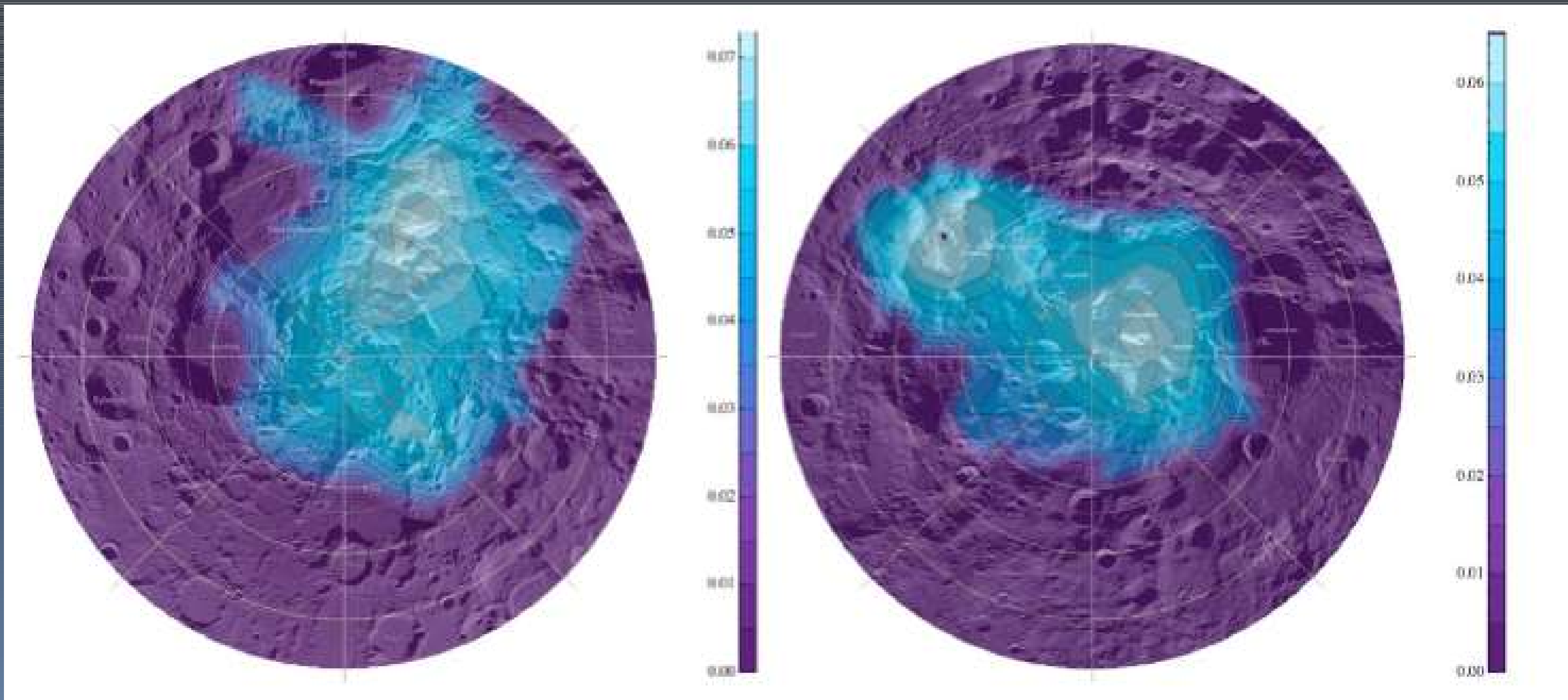


Modified from Lucey (2001)

Sources and Migration of Volatiles to Cold Traps



Polar Volatiles - Hydrogen



Neutron data – Hydrogen abundance (H, OH, H_2O, C_2H_6O)

Average 0.01% wt. water equivalent hydrogen poleward of 80° and in the top 1-2 m.

If water, it amounts to 9.8×10^{10} kg (1/1000 of Lake Tahoe).

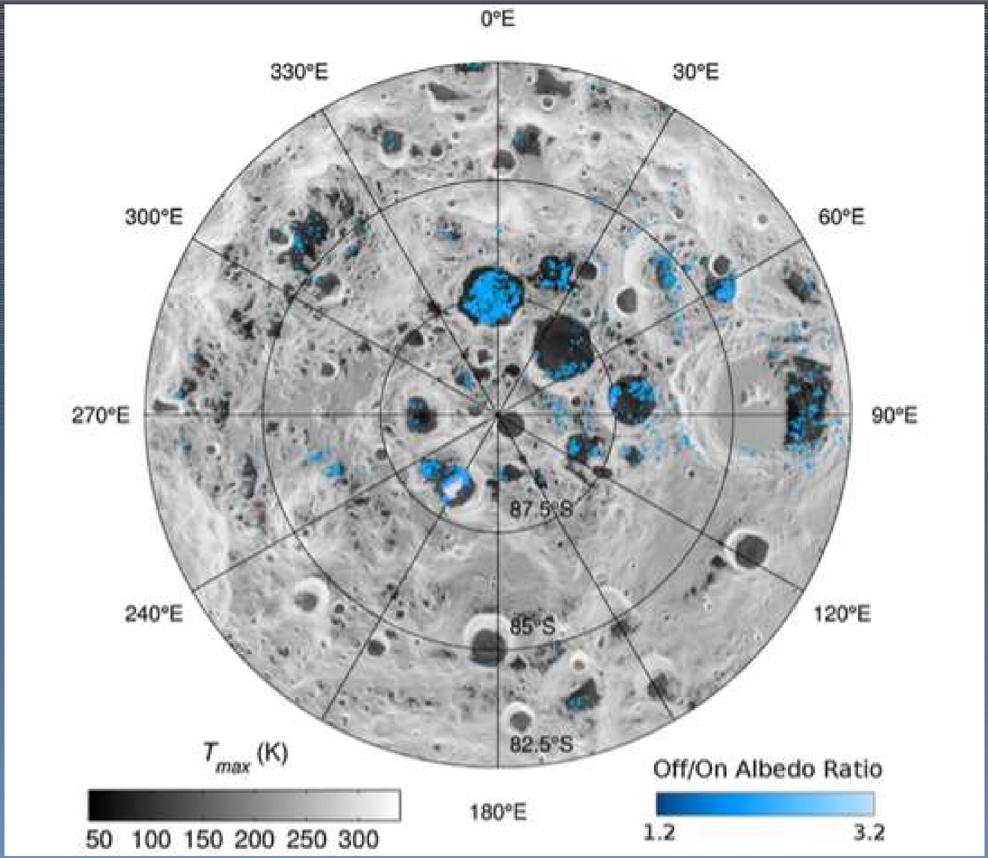
Polar Volatiles – Water Frost

Heterogeneous lateral distribution

Surface frost

- Signature of water ice at 165 nm - analysis shows surface frost is not evenly distributed in cold regions.

- LRO LAMP data - low illumination with very coarse spectral binning, thus are better as supporting data than standing alone.



Ultraviolet reflectance and temperature.

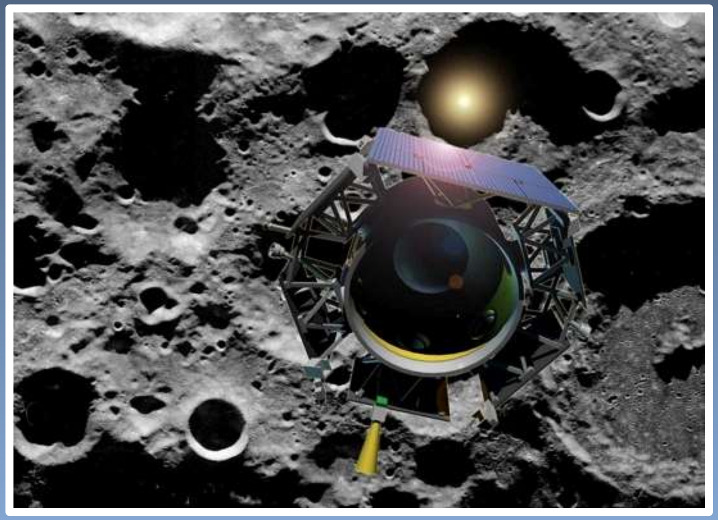
Volatiles - LCROSS Mission

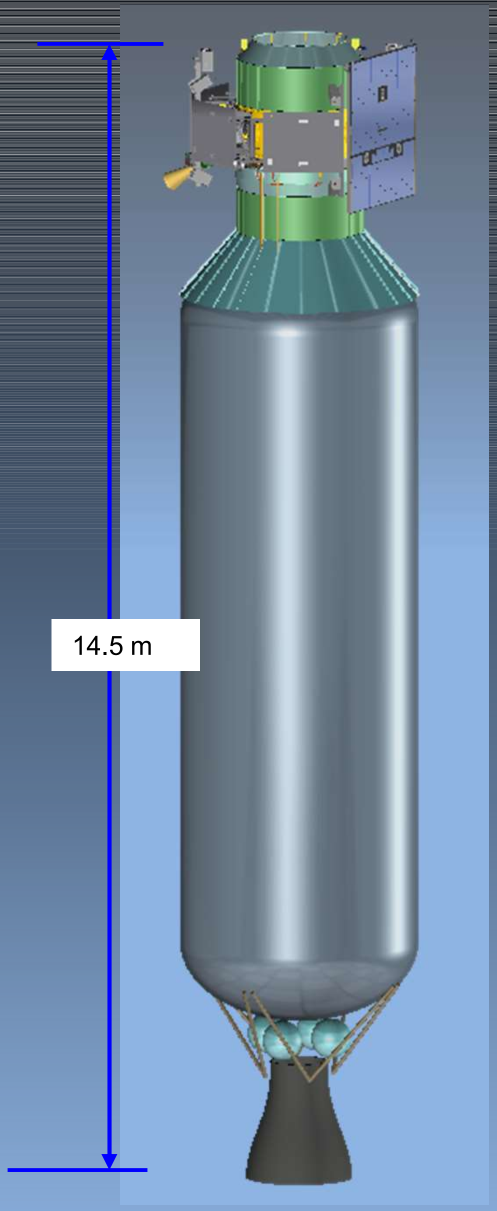
Shepherding Spacecraft

Guides and aims the Centaur to its target and carries all of the critical instrumentation.

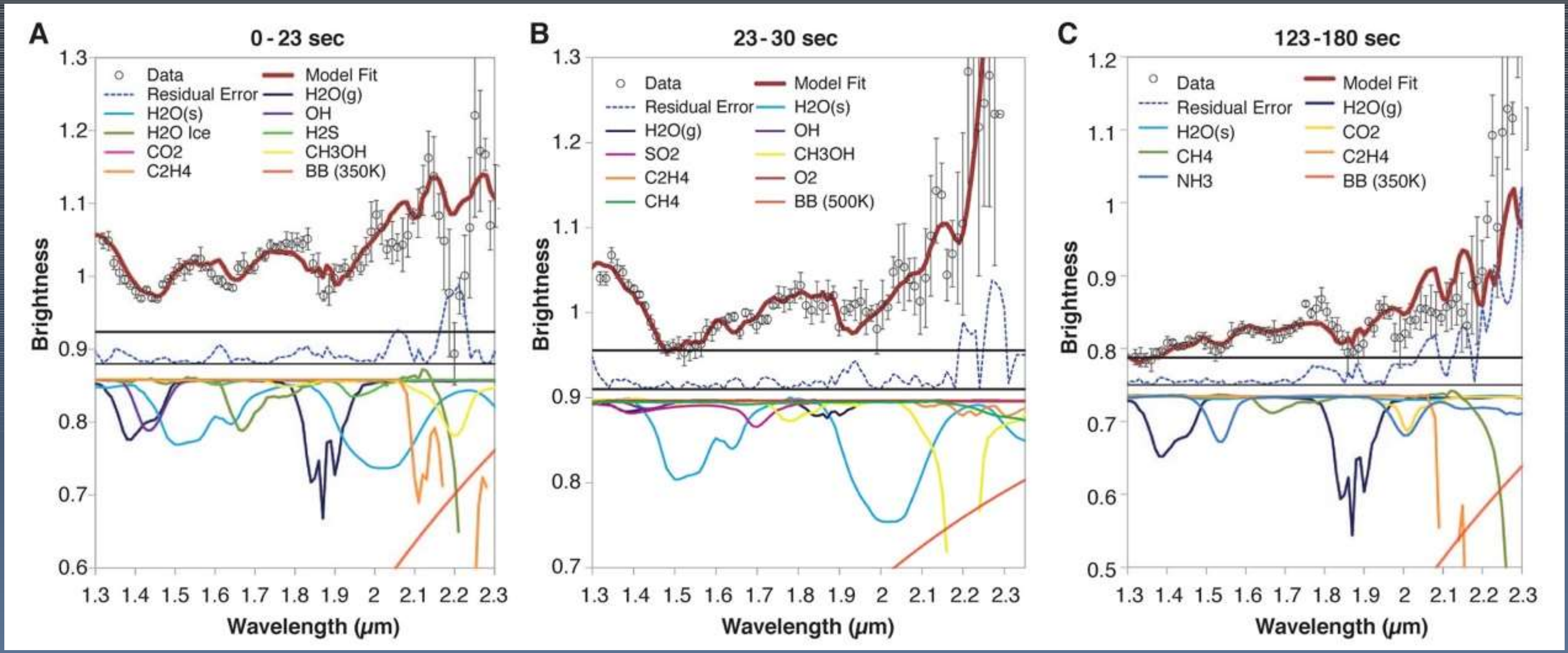
Centaur

Upper Stage: provides the thrust to get us from Earth orbit to the Moon and will then be used as an impactor





Volatiles – LCROSS Mission

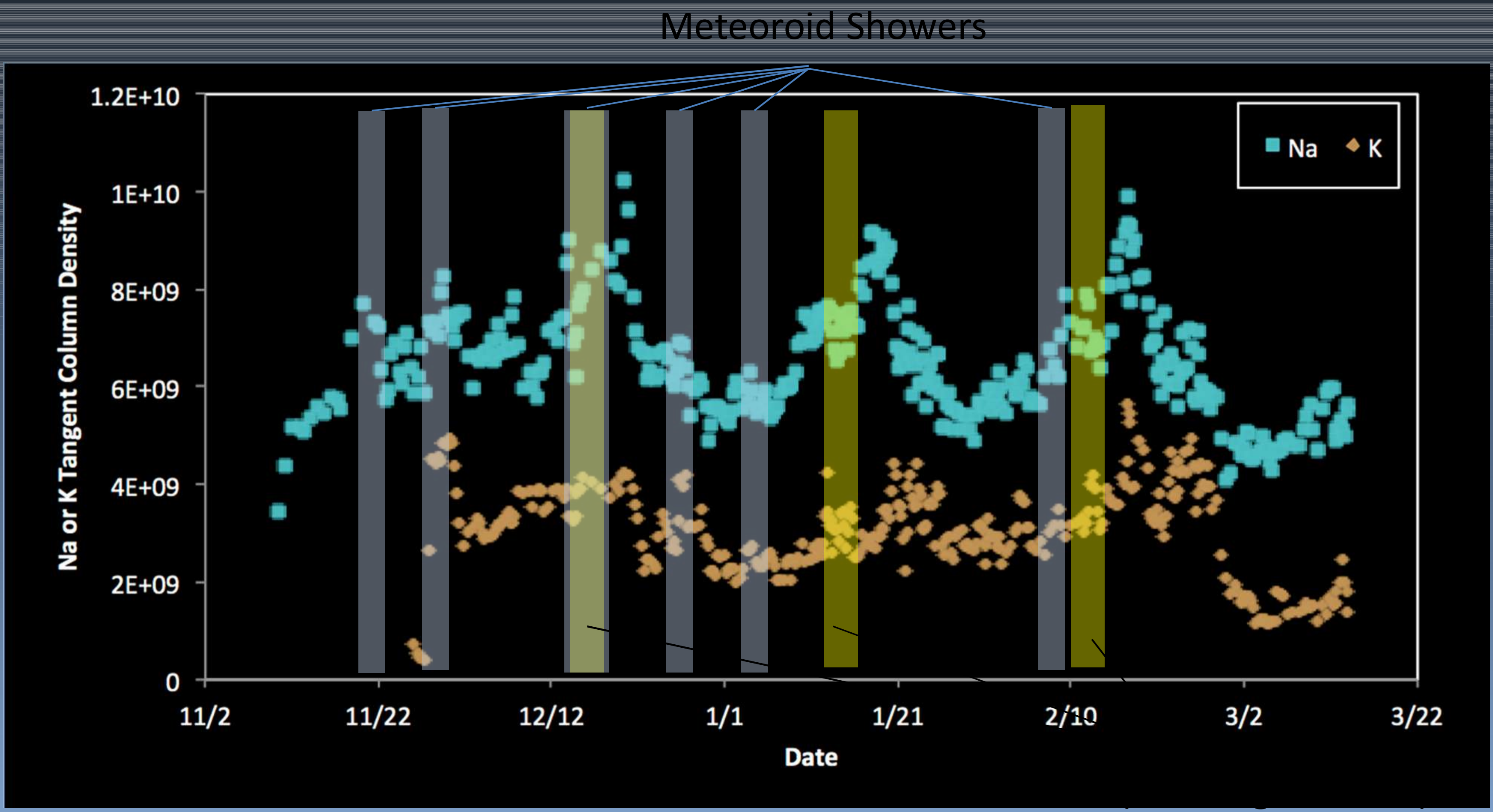


LCROSS impact into Cabeus

Spectral identification of H_2O in both solid and gas phases

- High resolution spectra provide strong evidence for the chemical composition.
- Lofted material into sunlight providing a strong illumination source.
- Question arises about any impact-induced chemistry and contributions from the impactor vs. the target material.

Volatiles – LADEE / UVS
Sodium and Potassium Observations

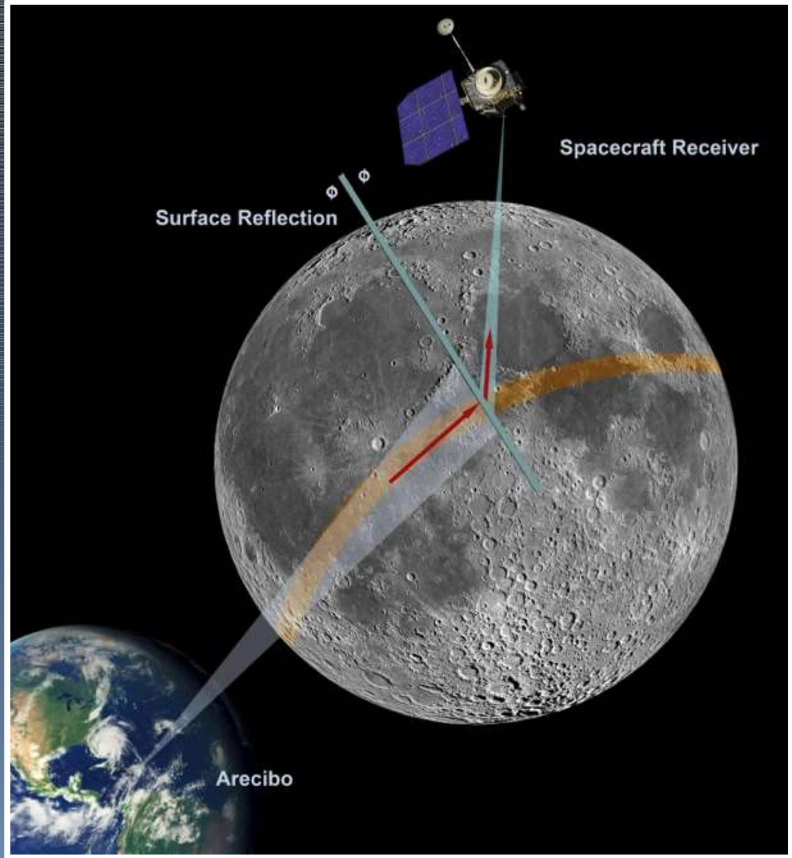


Mini RF – Bistatic Radar Observations

Mini-RF is currently operating in a bistatic mode, using the Arecibo Observatory or Goldstone as a transmitter

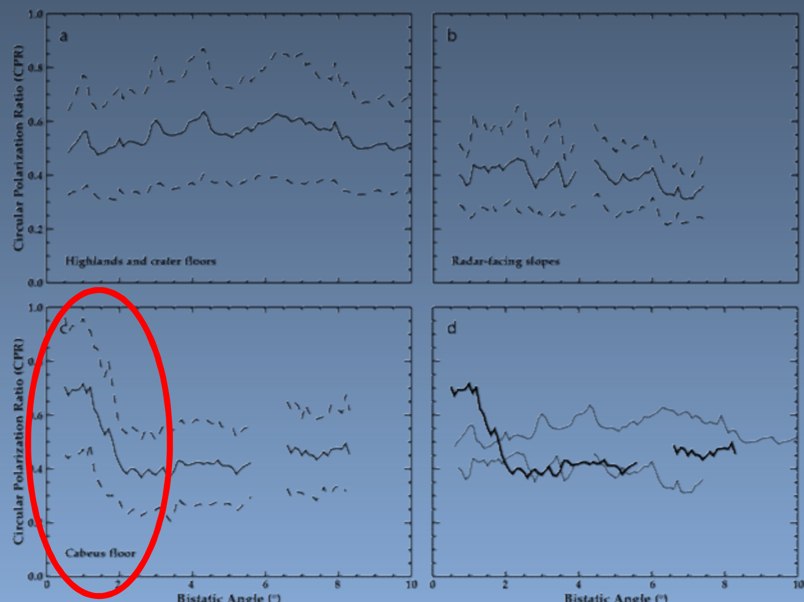
Experiment provides information on scattering properties of lunar materials as a function of beta (phase) angle

Within Cabeus Crater, there appears to be blocks of ice (~10 cm) in the subsurface.

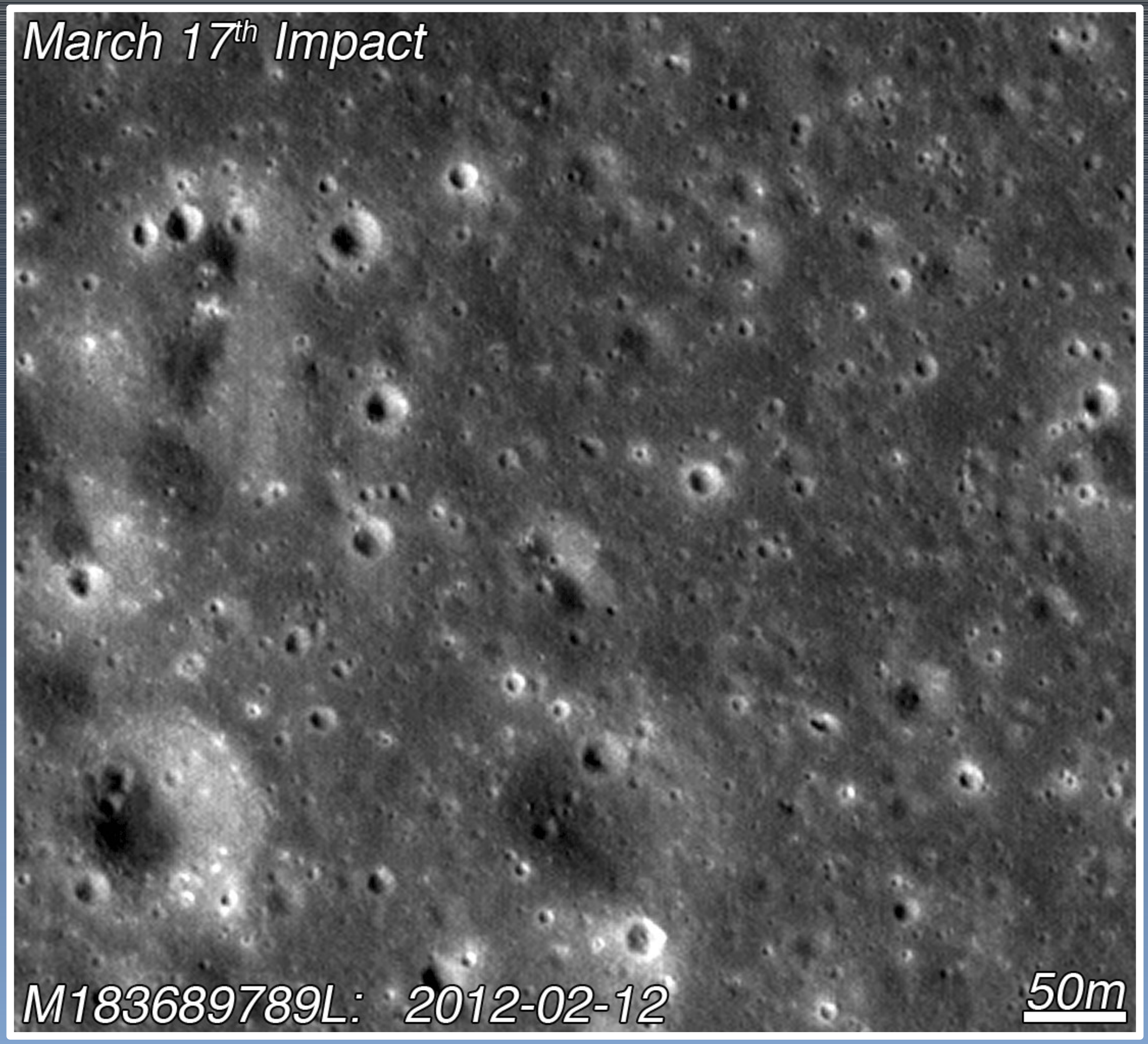


No ice

Ice

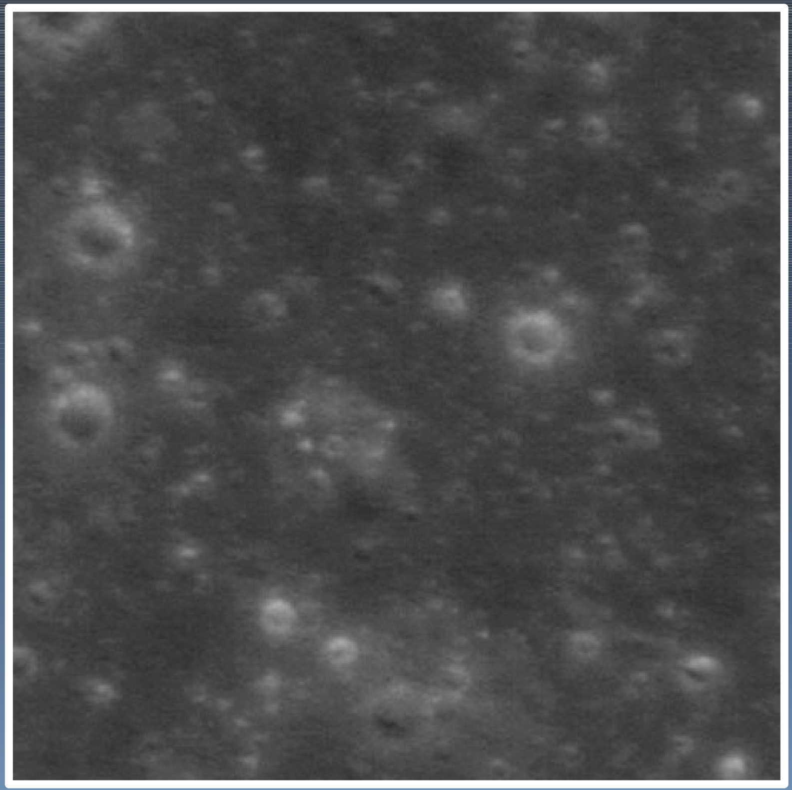


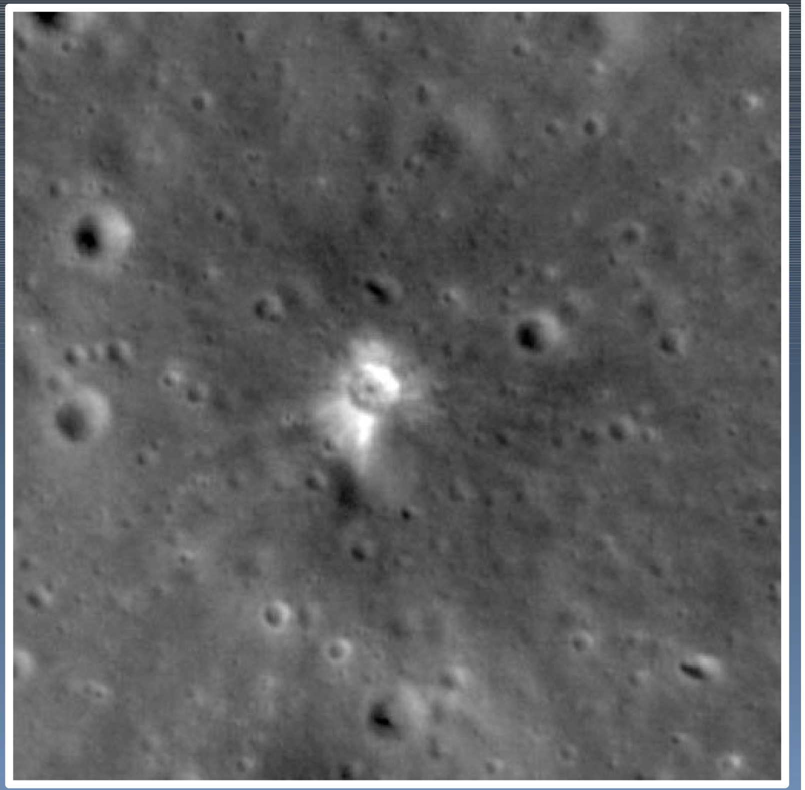
March 17, 2013



20 m diameter
40 kg meteoroid
0.3 - 0.4 m diameter
5 tons of TNT

March 17, 2013


Before

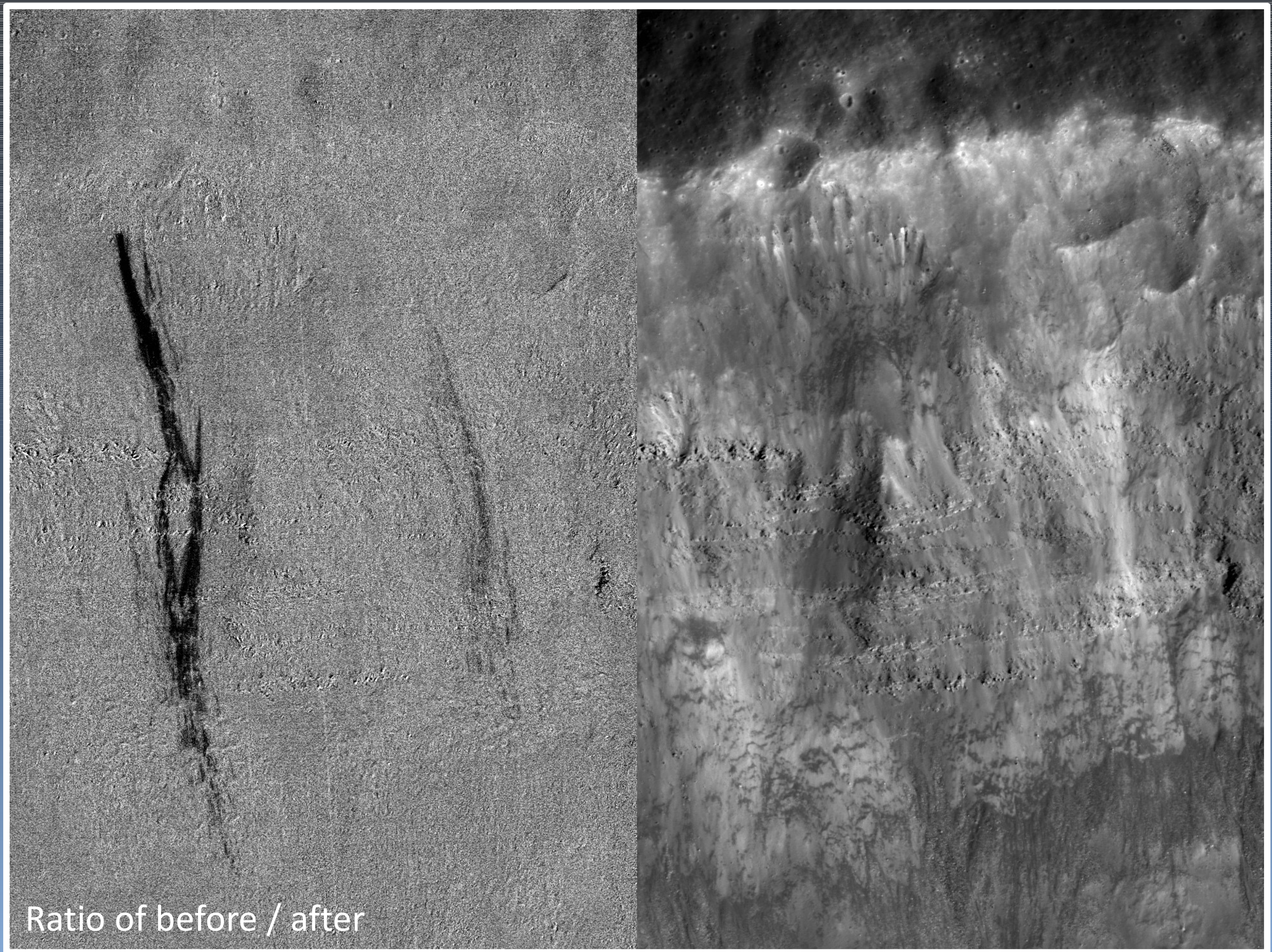

After

20 m diameter
40 kg meteoroid
0.3 - 0.4 m diameter
5 tons of TNT

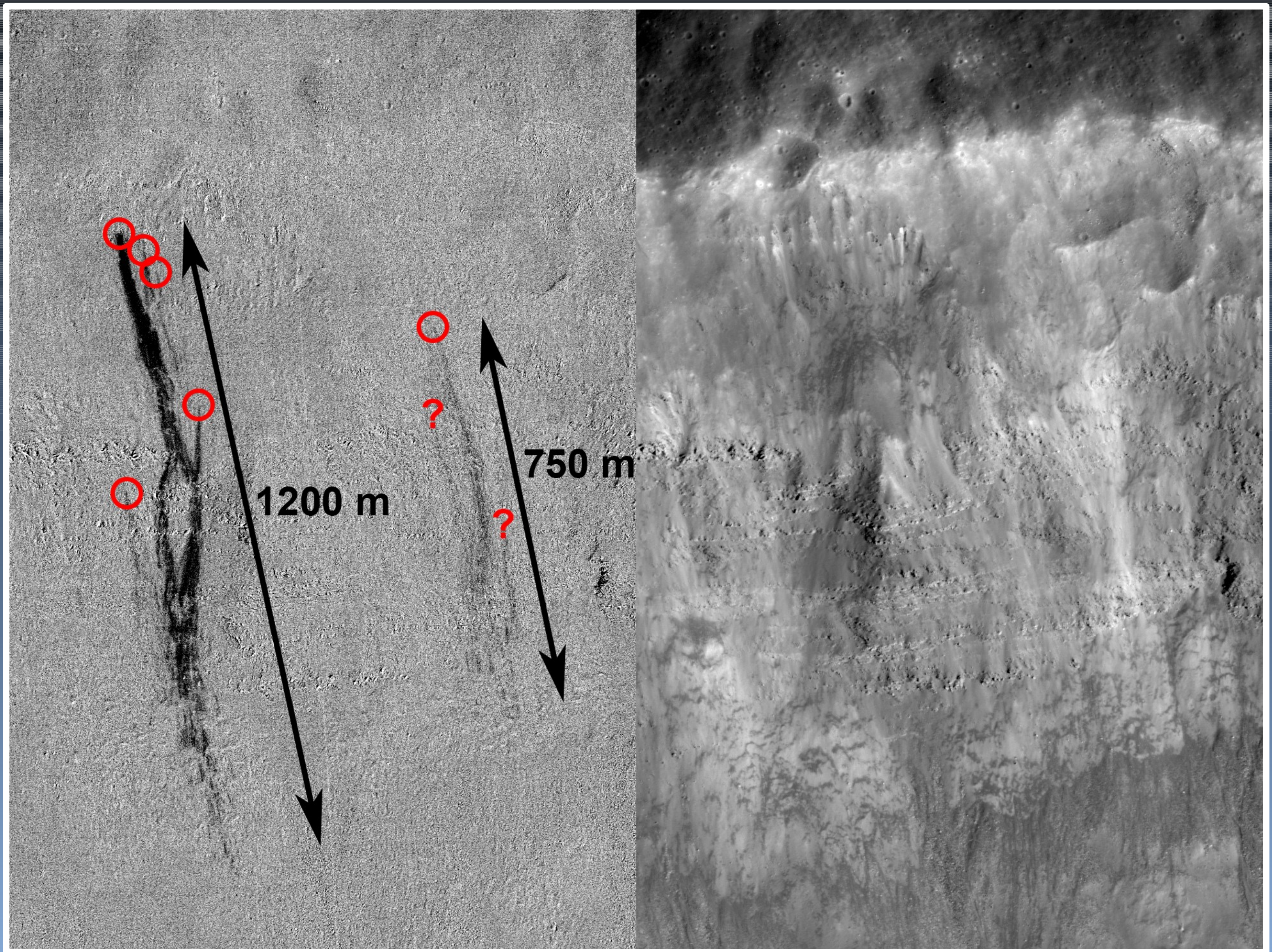
September 11, 2013

40 m diameter, 3-4 m deep, 0.6-1.4 m

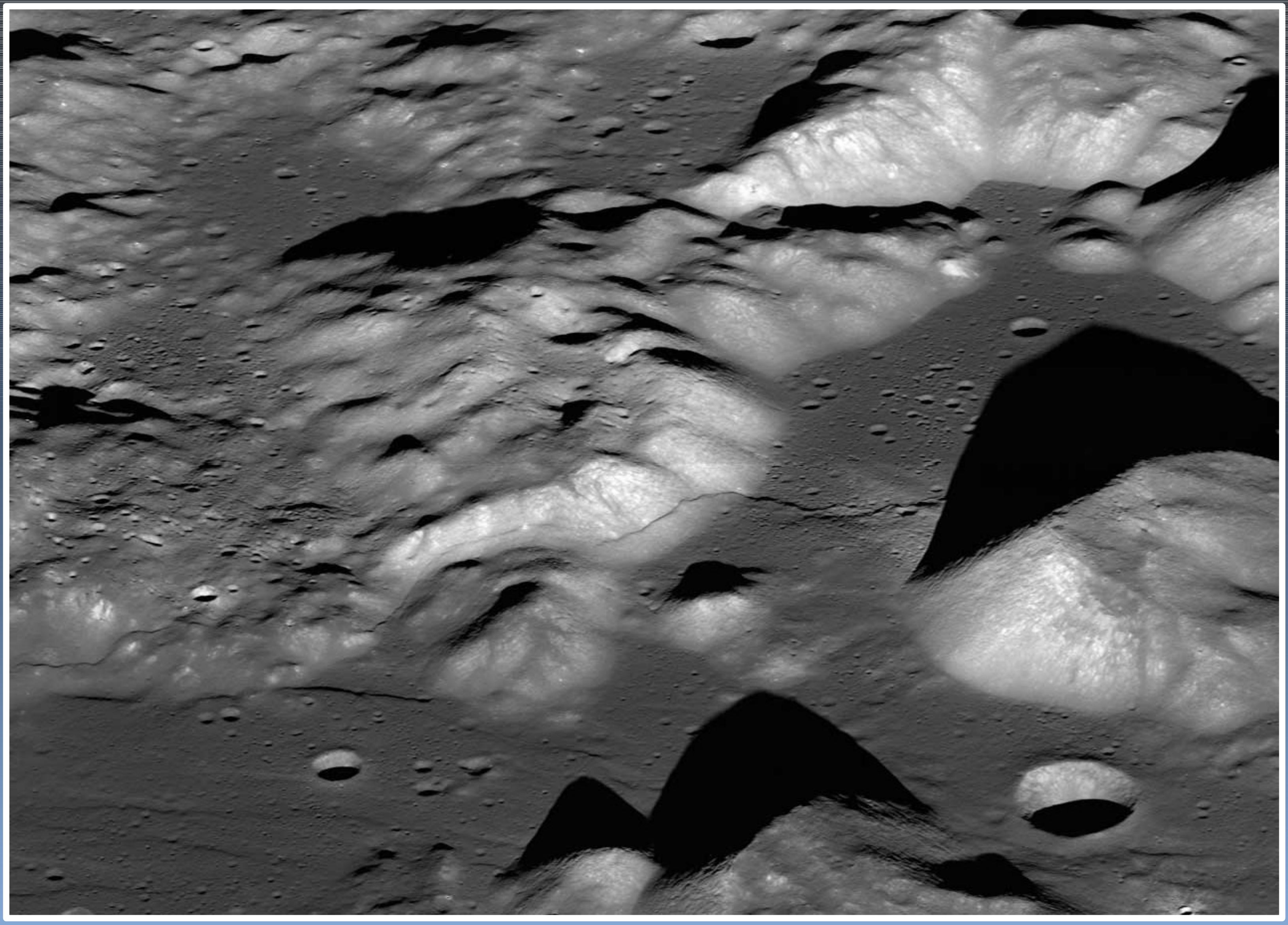
Landslides



Landslides

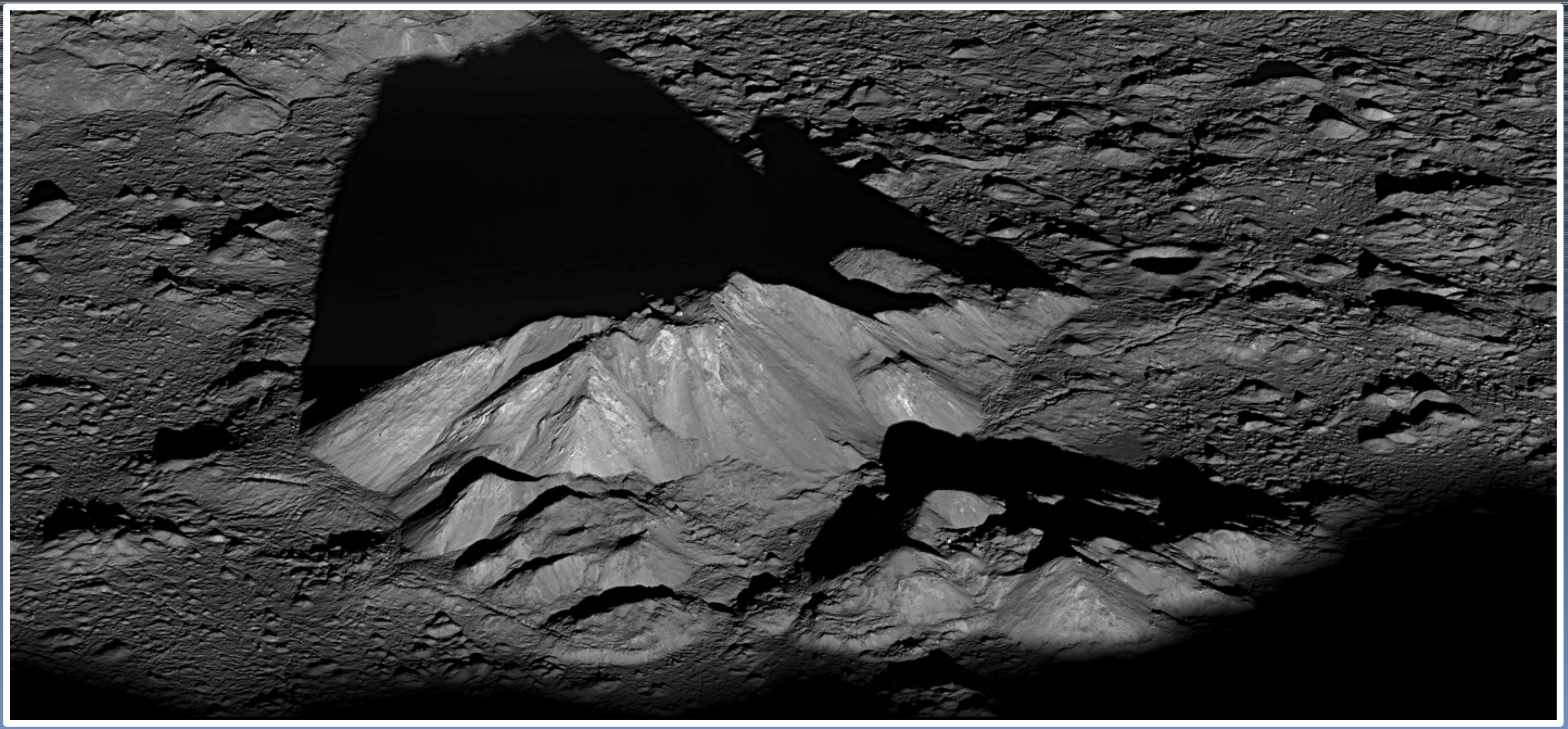


Apollo 17 Site



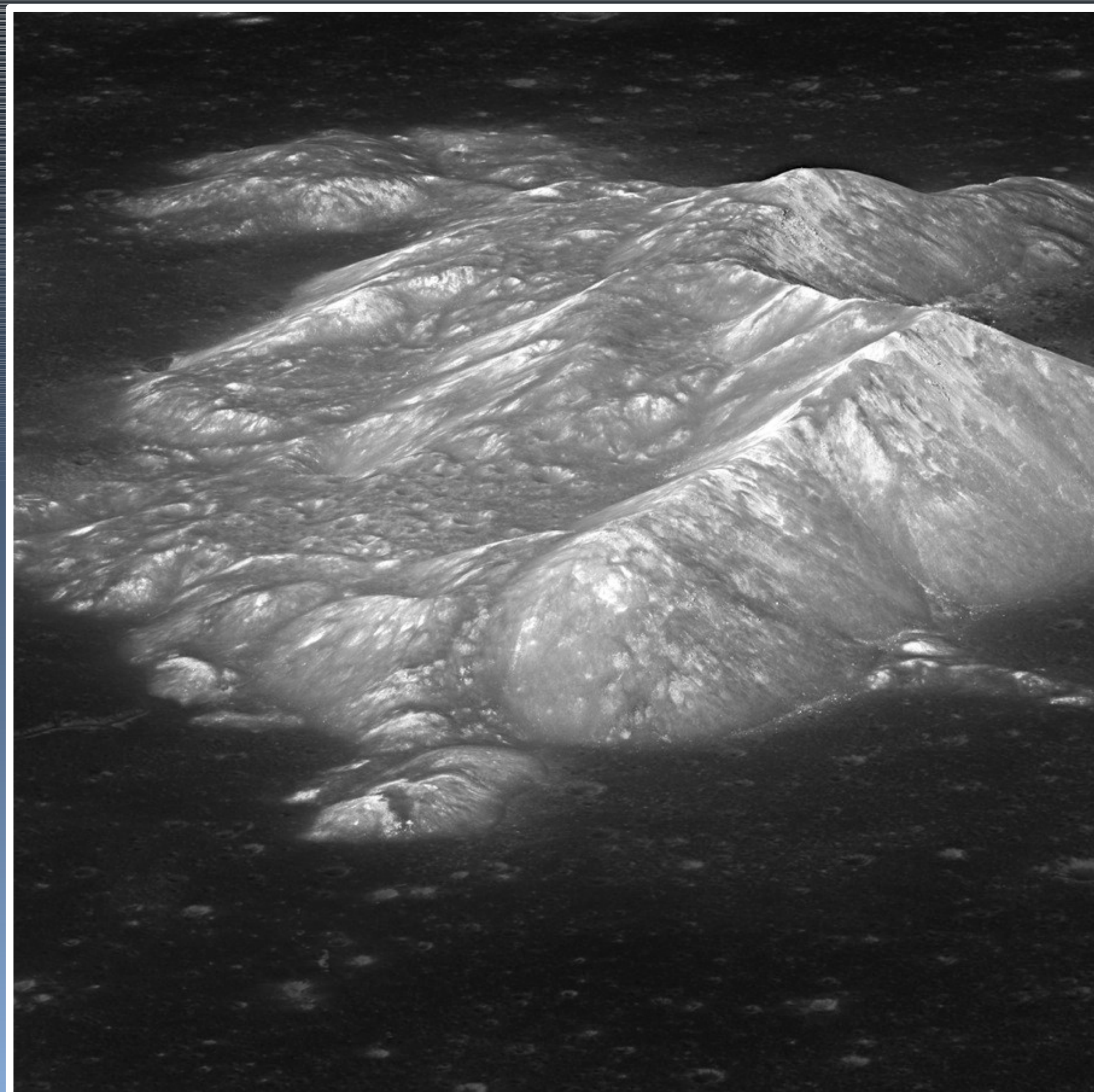
Giordano Bruno

Tycho

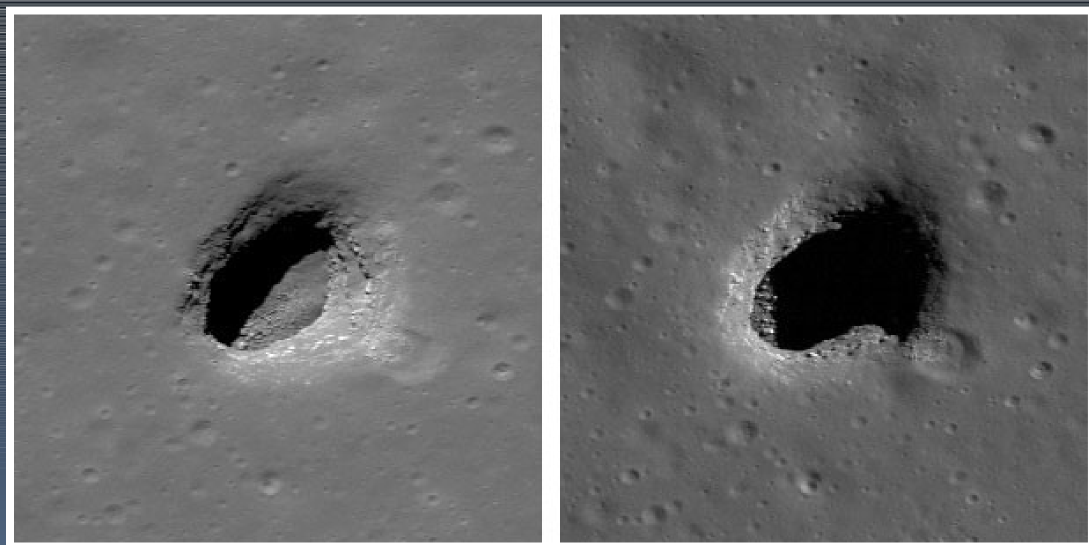


Tycho

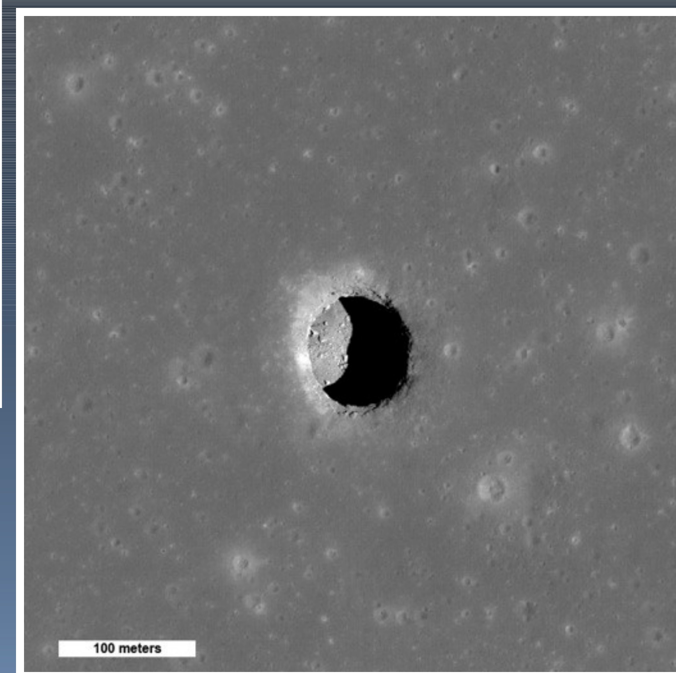
Tsiolkovskiy Central Peak



Pits



Mare Ingenii



Mare Tranquillitatis